THE UNIVERSITY OF ALBERTA

JOURNEY TO WORK PATTERNS
IN EDMONTON, 1971

by

(C) PATIENCE CHINYELU MONANU

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ABSTRACT

The provision of efficient transportation facilities, especially for the journey-to-work, is one of the greatest problems now facing urban centers. It is therefore becoming increasingly important to determine the factors that underly the journey-to-work patterns to major employment centers in urban areas, since they constitute an important component of the urban transportation problem.

The purpose of this study is to investigate the spatial pattern of the journey-to-work trips in Edmonton and to discover the factors significantly related to this pattern. The origin-destination statistics related to work trips, distance, travel time by transit and by automobile, car ownership ratio, parking cost and land use characteristics of the 234 Traffic Zones in the city for 1971, obtained from the City of Edmonton, Transportation Planning Branch, are used in this study. Five employment centers in the city were identified. These comprise the Central Business District, the University of Alberta and three (3) peripheral industrial zones located in the South east, North west and North east of the city, respectively.

The spatial pattern of the journey-to-work obtained shows that although each employment center identified receives work trips from all parts of the city, the effect of the Central Business District is dominant. The work trip catchment area of the Central Business District approximates the residential location pattern of the city whereas the remaining employment centers indicate a denser cluster of attraction in areas immediately surrounding them as well as a strong distance-decay effect.

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The provision of efficient transportation facilities, especially for the journey-to-work, is one of the greatest problems now facing urban centers. It is therefore becoming progressively important to determine the factors that underlie the journey-to-work patterns to major employment centers in urban areas, since they constitute an important component of the urban transportation problem.

The purpose of this study is to characterize the spatial pattern of the journey-to-work trips in Edmonton and to discuss the factors significantly related to this pattern. The origin-destination statistics related to work trips, (i.e., total trips by transit and by automobile), car ownership ratio, parking cost and land use characteristics of the 136 Traffic Zones in the city for 1971 obtained from the City of Edmonton, Transportation Planning Branch, are used in this study. Five employment centers in the city were identified. These comprise the Central Business District, the University of Alberta and three (3) industrial zones located in the South east, North west and North east of the city, respectively.

The spatial pattern of the journey-to-work obtained shows that although each employment center identified receives work trips from all parts of the city, the effect of the Central Business District is dominant. The work trip movement into the Central Business District approximates the conventional commuter pattern of the city whereas the remaining employment centers indicate a strong pattern of attraction to areas immediately surrounding them as well as a strong "distance-decay" effect.

The attractiveness of the Central Business District for work trips and, more importantly, the generation intensity of the zones which takes distance into consideration indirectly, are the most important variables related to work tripmaking to the Central Business District. Other variables do not improve the amount of variation explained by these.

The number of work trip origins and destinations and an appropriate measure of spatial separation are the variables that contribute most significantly to the explanation of work trips to the industrial zones. The introduction of other variables related to accessibility and land use density slightly improve on these models in the industrial zones, whereas they have no effect in the Central Business District. The socio-economic variables used, namely, parking cost at destination and car ownership ratio at origin fail to be significantly related to work tripmaking to any of the employment centers.

Attempts to develop models for the University of Alberta were unsuccessful. This may be attributed to the fact that the University attracts a variety of workers and students whose residential location decision is influenced by family and economic considerations and this gives rise to weak explanation using the variables available for this study.

The testing of the models indicates that they are relatively stable and that they seem to perform better for prediction when the values are aggregated according to Traffic districts instead of the smaller Traffic zones. However, a meaningful spatial pattern of distribution of residuals predicted from these models is not obtained.

It is therefore suggested that further attempts should be

The attractiveness of the Central Business District for each trip end, more importantly, the generating potential of the zones which these generate from residential locality, are the most important variables related to work tripmaking to the Central Business District. Other variables do not improve the amount of variation explained by them.

The number of work trip origins and destinations and an appropriate measure of spatial separation are the variables that contribute most significantly to the explanation of work trips in the intraurban model. The introduction of other variables related to accessibility and land use density slightly improve on these models in the industrial case, whereas they have no effect on the Central Business District. The socio-economic variables used, namely, parking cost at destination and car ownership ratio at origin seem to be significantly related to work tripmaking in one of the employment centres.

Attempts to develop models for the University of Alberta were unsuccessful. This may be attributed to the fact that the University attracts a variety of workers and students whose residential location decision is influenced by family and economic considerations and this gives rise to more randomness in the dependent variable for this study.

The testing of the models indicates that they are relatively stable and that they tend to perform better for prediction when the models are aggregated according to traffic districts instead of the smaller traffic zones. However, a meaningful spatial pattern of distribution of work trips predicted from these models is not obtained.

It is therefore suggested that further attempts should be

made to understand other factors underlying travel demand for the journey-to-work in Edmonton, in other directions which have not been accomplished in this study.

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CHAPTER I

INTRODUCTION

1.1 URBAN TRANSPORTATION

The city is characterized by specialized functions, centralized services as well as commercial, industrial and other related activities which are performed by a dense concentration of urban residents. This results in a heterogenous arrangement of population, economic activities and land use types within the city. In order to tie this entire complex of urban structure together as a system, an intricate network of transportation and communication linkages has developed.

The journey to work provides the critical link between the distribution of urban residents and the location of the employment centers in the city. Since work trips are the dominant category of journeys made from home, they constitute the source of the most serious traffic conjestion problems in the city. Problems of traffic overload are further aggravated by the fact that the journey to work is concentrated in time, occuring in the morning and afternoon peak hours of work days.

The provision of efficient transportation facilities, especially for the journey to work, is therefore one of the greatest problems now facing urban centers. The increased level of urbanization in the modern metropolis with the associated urban sprawl make it increasingly difficult for intra-urban transportation to provide the critical link between places of residence and the worksites. As the problems associated with the separation of work-residence location become more pressing and their solution more urgent, there arises an urgent need to determine the factors that underly the journey to work patterns to major employment

centers in the city.

An important factor that is significantly related to journey to work patterns is the spatial distribution of places of residence and places of employment in an urban area. Most researchers have found that distance and other measures of spatial separation such as travel time or cost are closely associated with work tripmaking, Work trip lengths are primarily related to the size and physical structure of the city, characteristics of the transportation network, and various social and economic factors.

There are, however other factors that may greatly modify the influence of these major factors on work tripmaking pattern. These include people's preferences and the fact that the modern metropolis allows the worker to change his employment without necessarily changing his residence. Also the widespread use of the automobile gives the worker the freedom to choose where he wants to live without regard to his place of work.

The journey to work is only one aspect of transportation and other movements that take place in urban areas. Intra-urban interaction in the form of spatial agglomeration of industries, institutional and manufacturing linkages as well as variations in the housing and employment opportunities in the city are some factors that may affect the residence-worksite location in various ways.

The journey to work is therefore not only a function of the spatial distribution of land uses in the city, but physical, social, economic, psychological and other related factors may complicate the pattern of work trips considerably. Despite these overwhelming complexities underlying people's adaptation to city space and the resulting

pattern of the journey to work, there is still the need to identify any regularities that may exist between residential location and work trip catchment areas of major employment centers in the city.

1.2 OBJECTIVES OF THE STUDY

The objective of this study is to investigate the relationship between residential location and place of work in Edmonton with an aim toward assessing the following points.

1. The spatial pattern of work trip distribution to major employment centers and their respective work trip catchment areas and work trip lengths.
2. The major factors affecting the work trip distribution pattern in the city.

1.3 ORGANIZATION OF THE STUDY

Chapter II discusses the spatial interaction models of travel demand related to trip distribution, especially for the journey to work, and the associated literature. It also presents a brief description of the Multiple Linear Regression model and variables which are commonly used in the analysis.

Chapter III presents a brief description of the major characteristics of the transportation system in Edmonton. It discusses the previous transportation studies in Edmonton which are related to work tripmaking and attempts to indicate the relevance of this study.

Chapter IV indicates the sources of data used in this study. It presents a brief description of the variables as given and the major

modifications of them adopted in the study. It also identifies the major employment centers in the city for which the analysis is undertaken.

Chapter V identifies the pattern of work trip attraction, work trip catchment areas and work trip lengths of the major employment centers.

Chapter VI presents the results of the analysis and the variables which contribute significantly to the explanation of the pattern of work trips.

Chapter VII discusses the results obtained from the analysis and the reliability of the models.

Chapter VIII presents a discussion of the findings, and draws conclusions from them. In addition, recommendations for future research are made.

CHAPTER II

TRAVEL DEMAND MODELS AND VARIABLES

2.1 GENERAL REVIEW

The wide variety of models and variables that one encounters in the field of travel demand estimation results in part from the scarcity and heterogeneity of data. Many studies of travel demand involve the formulation of the transportation demand function according to *a priori* economic theory and others depend on the careful stratification of the population and subsequent extrapolation of the travel properties observed within the stratified samples. Consequently a large degree of standardization has not been achieved.

Travel demand models are used to describe the functional relationships between tripmaking on the one hand and socio-economic and transport system characteristics on the other. A general demand function expresses the relationship between the quantity of a service or good consumed or purchased and the price of that good or service. The commodity demanded in travel demand models is the trip and in this particular study it is the work trip. The price that is paid in order to satisfy this demand includes the travel time, travel cost and inconvenience associated with the trip. The need for intra-urban transportation arises from the spatial distribution of different uses of land in an urban area, although the location of transportation facilities, in turn, affects the spatial pattern of distribution of these uses of land.

In examining the functional relationships between tripmaking and socio-economic and transport system characteristics, important factors to be taken into consideration include the scale and relative intensity of trip generation and attraction, intervening opportunities and measures

of accessibility. Travel demand models are developed using appropriate explanatory variables reflecting these and other factors which influence urban travel behaviour. Depending on the type of study being made, a consistent approach used in the choice of variables is to ensure that the variables chosen (1) take planning policies into account, (2) are plausible with regard to the travel behaviour of urban tripmakers and (3) are relatively stable and predictable. Since the aspect of travel demand being considered in this study is related to the factors that influence work trip distribution to major employment centers in the city, the variables chosen for this study reflect this.

A large variety of mathematical forms have been used to develop direct passenger travel demand relations. The simplest form is that in which tripmaking is regarded as a simple linear function of price, travel time and other factors related to tripmaking. Other mathematical forms with different implications include the semi-logarithmic form in which the log of the quantity demanded is expressed as a linear function of price and travel time, and the hyperbolic or log/log form which describes the logarithm of the quantity demanded as a linear function of the logarithm of travel price, travel cost and other factors related to work tripmaking. Quandt and Baumol (1966) have indicated the close relationship between the log linear form of travel demand model and the traditional gravity models. Both linear and logarithmic forms are used in this analysis.

2.2 STAGES OF TRAVEL DEMAND ANALYSIS

From the relevant available transportation planning literature, there has evolved a relatively standard format for transportation planning based on the hypothesis that there is a stable relationship between

transportation and the urban activity system. This format is called the "Urban Transportation Planning (UTP) Package" and it generally comprises four models, namely, trip generation, trip distribution, modal split, and trip assignment, and these are subsequently discussed. Researchers, however, do not agree on the precise sequence of the four models. For example, Martin, Memmott and Bone (1961) suggest that modal split should come after the trip generation phase, before distribution, while Davis (1969) insists that modal split should follow the trip distribution phase. This dichotomy arises because of the existence in urban areas of two essentially separate submarkets for public transport patronage and it also depends on the stage in the UTP package at which modal split is considered. Modal split models developed before the trip distribution phase are called "trip-end" modal split models while modal split models that follow the trip distribution phase are called "trip-interchange" modal split models.

Trip generation analysis is concerned with relating the intensity of trip productions by household or residential zone to trip attractions to non-home based activities such as employment, retail facilities and industry.

Trip end modal split models allow the trip ends estimated in the trip generation phase to be partitioned into two major groups, namely, captive tripmakers who have no access to a car for a trip and choice tripmakers who have a choice between using a car and using public transit for a particular trip. They are based on the assumption that transit patronage is relatively insensitive to the service characteristics of the transport modes. The modal patronages are primarily associated with the socio-economic characteristics of the tripmaker and the emphasis is

on identifying the transit captives. The modal split model developed by the South East Wisconsin Transportation Study (1966) is an example of the trip end modal split model.

Trip-interchange modal split analysis simulates the manner in which choice tripmakers travelling between an origin and destination pair choose between the use of a car and the use of public transport for the trip. It considers the relative service characteristics of competing modes as well as measures of the socio-economic characteristics of the tripmakers. The modal split models developed and used in two major transport studies in Toronto by Hill and Von Cube (1963) and by the Traffic Research Corporation of Toronto (1967) as well as the Bureau of Public Works model using data on work trips in Washington D.C. (1965) are examples of this type of model. The underlying structures of these two types of modal split model exhibit considerable similarity, but on close examination it is seen that the models do not distinguish clearly between captive and choice riders of public transit.

The purpose of trip distribution analysis is to synthesize the trip linkages or interchanges for both transit captive and non-captive tripmakers between traffic zones. Trip assignment analysis enables the car and transit trips between origin and destination pair to be distributed over the links of their respective networks. The major concern here is with methods of assigning traffic to various routes.

Although comprehensive transportation study models involving the four sub-models are being continually improved, the major drawback of the use of the UTP package is its assumption that the stages of the various sub-models are sequential. This assumption imples that the tripmaker's decision about whether to take a trip, where to take it to,

and by what mode and route to take the trip are separate unrelated decisions faced by tripmakers rather than simultaneous inter-related decisions. Also, these demand models, as they are expressed in the UTP package, hold the amount of tripmaking constant and vary only the split among attraction zones, modes, and routes.

This research is primarily concerned with the pattern of the distribution of work trips to major employment centers in the city and goes on to discuss the various associated travel demand models.

2.3 GENERATION AND DISTRIBUTION MODELS

Multivariate regression models have been widely used for the study of trip generation and distribution aspects of travel demand. The demand equations can be considered to be linear, hyperbolic, or exponential but each has the following general form:

$$A = b_o + b_1 X_1 + b_2X_2 + \text{----}\ b_nX_n + e$$

where:

A = Work trips produced in trip generation analysis (or its logarithm)

or

A = Demand for transportation between zones i and j in trip distribution analysis (or its logarithm)

$X_1, X_2 - - - - X_n$ = Measures of independent variables (or their logarithms)

b_o = Constant term

$b_1, b_2 - - - - b_n$ = Coefficients of multiple regression

e = Error term

For these models, the usual assumptions of linear regression - linearity,

independence of observations, normality, and homoscedasticity, apply.

Unfortunately, the predictive abilities of such regression models are generally poor, largely because data restrictions have prevented more than cross-sectional glimpses at the regression parameters, but, they are useful for identifying useful associations. Also, the use of regression equations based on zonally aggregated measures of the zonal characteristics tend to submerge important characteristics of travel demand. The major advantage of multivarite regression models is that they enable a large number of variables that are related to travel demand to be considered together. Multiple Linear regression is considered adequate for this analysis and a more detailed discussion of it is presented below.

Category analysis, an alternative method of trip generation analysis, helps to reduce the problems caused by zonal aggregation since it estimates the trip production characteristics of separate categories according to a set of properties that characterize the households. Wooton and Pick (1967) apply this model to trips generated by households in Metropolitan Toronto. It is not appropriate for this analysis which is not primarily concerned with trip generation.

Trip distribution models, in synthesizing the trip linkages between traffic analysis zones, ensure that any trip distribution matrices arrived at satisfy the production and attraction trip-end constraint equations. The Fratar growth-factor method (1954) estimates the trip interchange matrix by assuming that a future horizon-year matrix is proportional to the base year matrix modified by the trip end growth patterns of zones under consideration. The major deficiency of the technique is that the trip matrices estimated from it are insensitive to changes in

the properties of the transportation networks. It is used mainly for forecasting.

Three stochastic trip distribution models are used to estimate trip distribution patterns by synthesizing a matrix containing the probabilities that a trip produced in a given origin zone will find an attractive opportunity in a specific destination zone. These probabilities are derived from a knowledge of the distribution of attraction opportunities in an urban area and the travel time properties of the area. Each of these stochastic models namely, the gravity model, the intervening opportunities model, calculate these probabilities in a different way.

(a) The Gravity Model

The gravity model is a derived expression used in traffic generation and distribution studies. The model arises from the concept of demographic gravity and in its purest form is analogous to the Newtonian law of gravity. The basic premise of the gravity model as used in urban transport studies is that the trip interchange magnitude between two zones i and j is directly proportional to the number of trips produced in zone i, the number of trips attracted to zone j, and inversely proportional to some function of the spatial separation between the two zones. This premise is expressed algebraically as follows:

$$T_{ij} = k \frac{P_i \ P_j}{d_{ij}^b}$$

where:

T_{ij} = Demand for transportation between zones i and j (force of demographic gravity)

O_i, D_j = Population (masses) of i and j

d_{ij} = Distance or appropriate measure of spatial separation

between zones i and j.

b = Distance-decay exponent (2 in Newtonian Physics)

k = Gravitational constant.

In the general gravity model, the demand function is such that the log of demand is linear in the log of the socio-economic, geographic, and demographic variables of the origin and destination pairs. In the gravity model, the relative attractiveness of a zone is derived as the product of the number of opportunities in a zone and the travel time factor of that zone divided by the sum of this product for all the zones of potential attraction. The critical element of this procedure is the identification of the travel time factor function which reproduces the observed trip length frequency distribution. Area wide travel-time factor functions are normally used, but improved interchanges can be obtained if the gravity model is used in conjunction with trip ends which have been disaggregated into a number of socio-economic groups.

Several attempts have been made to provide theoretical justification for the gravity model. Niedercorn and Bechdolt (1969) demonstrate that the gravity model may be logically derived from the economic principle of utility maximization.

Wilson's (1969) derivation of the gravity model using the entropy maximization technique yields a gravity model with a negative exponential travel time factor. It also makes use of balancing factors to ensure that trip end constraints are satisfied. Wilson (1971) shows that the gravity model is not a single model but that there is a whole family of spatial interaction models which can be derived by using the entropy maximization technique. He bases his derivation on the

principles of information theory and on the assumption that the probability of a distribution occurring is proportional to the number of states in the system which give rise to that distribution, subject to a number of constraints.

(b) Intervening Opportunities Model

The basic hypothesis of the intervening opportunities model is that the number of trips from an origin zone i to a destination zone j is directly proportional to the number of opportunities at the destination zone j, and inversely proportional to the number of intervening opportunities (Stouffer, 1940). This hypothesis is expressed as follows:

$$T_{ij} = k \frac{a_j}{v_j}$$

where:

T_{ij} = Demand for transportation between zones i and j

a_j = Total number of destination opportunities in zone j

v_j = The number of intervening destination opportunities between zones i and j

k = A proportionality constant to ensure that all trips with origins at zone i are distributed to destination opportunities.

The intervening opportunities model calculates the relative attraction of a zone from the product of the cumulative probability of a trip which has not found a satisfactory destination after a set of distribution opportunities has already been considered, and a conditional probability that a satisfactory destination opportunity will be found in the set of opportunities within the zone being considered.

Schneider (1960) suggests a modification of the original model

in which the conditional probability is constant. Golding and Davidson's (1970) formulation assumes that the conditional probability decreases as additional trip ends are considered. Ruiter (1967) uses this model in a study of journeys to home from the central zone of Chicago. Swerdloff and Stowers (1966) use it in the study of distribution of residential locations of Central Business District employees in Greensboro, North Carolina. Pyers (1965) notes the problems connected with attempts to calibrate the model, using 1948 travel data for Washington, D.C. Whereas the model gives good agreement between the observed and the simulated average trip lengths, it performs very poorly when used to estimate trip lengths.

(c) Competing Opportunities Model

Tomazinis (1962) has proposed the competing opportunities model in which attraction trip-end probabilities are calculated as the product of the probability of attraction and the probability of satisfaction. The model is of this general form:

$$T_{ij} = P_i \, (pra_j) \, (prs_j)$$

where:

T_{ij} = Demand for transportation between zones i and j

pra_j = Probability of attraction to zone j

prs_j = Probability of trip-end allocation satisfaction in zone j

P_i = Probability of trip ending in zone i

The probability of attraction to a given zone is equal to the total number of attraction opportunities in a zone divided by the number of attraction opportunities in time bands up to the time band in which the zone is located. The probability of satisfaction is equal to one minus

the total number of attraction opportunities already considered divided by the total number of attraction opportunities in the study area. A generally satisfactory method of calibrating the competing opportunities model has not been developed.

Heune and Pyers (1961) have examined the three stochastic trip distribution models by comparing the observed and the estimated trip length frequency distribution from the calibration of each model. The results of this study indicate that the gravity model is the most reliable and is the simplest of all three to use and to calibrate. For certain types of special trip distribution problems, however, the other techniques might be more satisfactory. Although there is not yet any theoretically justifiable explanation for the wide variation in the values of k and b in empirical work, the gravity model still commands a significant spot in transportation demand studies. It is used in a modified form in this analysis by employing the measures of trip production and attraction as well as measures of spatial separation and other variables related to work tripmaking behaviour.

(d) Linear Programming Approach to Trip Distribution

The Transportation Problem of linear programming has also been used in trip distribution analysis. The objective function is to minimize the total amount of time spent by tripmakers in moving between origins and destinations. The objective function is as follows:

$$\text{Minimize} \quad Z = \sum_{i}\sum_{j} d_{ij}\, t_{ij}$$

where:

t_{ij} = Demand for transportation between zones i and j

d_{ij} = Distance between zones i and j

subject to the constraints,

$$\sum_j t_{ij} = b_i \text{ (for all i)}$$

$$\sum_i t_{ij} = a_j \text{ (for all j)}$$

$$\sum_i b_i = \sum_j a_j$$

and $$t_{ij} \geq 0,\ b_1 \geq 0,\ a_j \geq 0 \text{ (for all i,j)}$$

Evans (1970) illustrates how this problem can be solved by using the classical Transportation Problem of operations research. Evans (1973) also discusses the relationship between the gravity model of trip distribution with exponential cost function and the transportation problem in linear programming. She shows that in the solution of the gravity model, as the exponential cost function or the parameter α (alpha) tends to infinity the solution tends to a limit, which is the cost minimization solution of the linear programming transportation problem.

Although the validity of the linear programming approach rests on the assumption that urban tripmakers select origin destination pairs so as to minimize the total amount of time spent in the system, empirical evidence suggests that they do not behave collectively in this way. However, the linear programming technique performs better when it is used for analysing trip ends which have been stratified according to socio-economic groups. The work trips used in this study are not stratified according to socio-economic groups and the linear programming approach is not used.

2.4 WORK TRIP DISTRIBUTION MODELS

Work trips have received special consideration in the litera-

ture because they are the most important category of journeys made from home and because work trips tend to be distributed unevenly through the day, being concentrated into a few peak hours.

(a) Accessibility and Urban Residential Location Models

Many residential location models, based on the simple notion of accessibility, tend to explain housing consumer behaviour largely in terms of minimizing the journey to work. In these models, the major factors that determine locational decision and quantity of residential space consumed are household incomes, preferences for residential space and unit price of residential space.

Alonso's (1960) theory of land rent has an accessibility bias and he emphasizes that households trade off accessibility for cheaper land. Herbert and Stevens (1960) have designed a linear programming model for allocating households to residential land in an optimal configuration with special reference to the Penn-Jersey Transportation Study. Kain (1961) indicates that households modify their desire for proximity to work place and their desire for low density housing by expanding their journey to work. Wingo's (1964) residential location model notes that locational equilibrium is achieved through the process of substituting transportation costs for space costs by the households in the urban area. He argues that this enables a balance to be achieved between the spatial pattern of employment centers and the various residential densities in the city. Lowry (1965) has formulated a model of the metropolis which emphasizes the control of major employment centers or activity nodes upon the spatial pattern of residential densities.

Stegman (1969) questions the pre-eminence of accessibility in the residential location process. He argues that residential location models with an accessibility bias tend to confuse the behaviour of the

urban land market with that of the urban land consumers while they are quite distinct. Using empirical evidence, he shows that neighbourhood considerations are more important to residential location than accessibility to place of work. In fact, it can be shown that large numbers of suburban families do not have to trade off accessibility for savings in location rent since they can have both. In this analysis, adequate measures of accessibility are employed.

(b) Socio-Economic Factors Affecting Work Trip Distribution

Liepmann (1944), Thompson (1950) and Westergaard (1957) studied the social and economic costs of work journeys and pointed to the need to minimize the residence - worksite separation. Schnore (1954) has emphasized that the costs incurred in the journey to work are major determinants of residential location and consequently most workers attempt to minimize the length of the journey to work. Vance (1960) has formulated a theory of urban spatial structure in terms of the journey to work. He postulates that changes in transportation technology affect the pattern of work trip distribution. Wolforth (1965) put forth a simple framework or categorization of the distributions of homes and work places in an urban area. Studies by Niedercorn and Kain (1962) and Hurst (1969a) indicate that sociological as well as economic factors enter into the work journey decisions. Voorhees, Bellamo, Schofer, and Cleveland (1968), using travel data from a number of cities in Canada (including Edmonton) and U.S.A. have revealed that urban travel as measured by the length of the work trips (measured in miles or minutes) is primarily related to the size, physical structure of the city, characteristics of the transportation network, and various social and economic factors. However, there is some indication that this is in fact an oversimplification and

the work of Lansing and Mueller (1964) note in particular that behavioural aspects may have some greater influence on residential site decision making than would seem apparent. Variables related to behavioural aspects of work tripmaking are unavailable but other socio-economic variables affecting work tripmaking are used in this study.

(c) Spatial Pattern of Work Trip Distribution

Some of the major approaches used in the social sciences in analysing the complex relationship between the journey to work and the spatial structure of the city include the use of demographic and ecological notions. The journey to work as a demographic problem is concerned with identifying the labor catchment areas of particular work places or groups of work places. Vance (1960) presents a theoretical model of labor catchment areas in the city. As a problem in human ecology the notion of subclusters within the larger whole is used to reflect the different patterns of residential densities associated with the Central Business District and other major employment areas in the city. Carroll (1952) has observed that the residential distribution of the former approximates that of the population of the entire urban area while the non-central work places draw their employees from their immediate vicinity. Hurst (1970) has substantiated this pattern in a modest way for the small urban area of Perth, Australia. The works of Schnore (1954) and Duncan (1956) are other studies in which the journey to work is treated within an ecological framework.

It is therefore recognized that the Central Business District and peripheral employment centers constitute separate components of the aggregate pattern of metropolitan traffic flow. This fact is taken into consideration in delineating the major employment centers in the city. The multiple linear regression model used in the analysis is

discussed in greater detail below.

2.5 MULTIPLE LINEAR REGRESSION ANALYSIS

Multiple linear regression models have been widely used in geographic research for deriving inductive generalizations about the covariation of spatially distributed phenomena. The multiple regression method and its application to research by geographers is discussed by McCarthy *et al.* (1956), Taaffe (1959), Thomas (1960a), Robinson *et al.* (1961), Russwurm (1964), Cox (1968), Kariel (1963), Chorely and Hagget (1967) and King (1969). Advanced and rigorous description of the mathematics underlying the multiple regression model as well as the general heuristic mathematical approach to the method are discussed in many standard statistics texts such as Anderson (1958), Hoel (1960), Blalock (1960), Draper and Smith (1966). The SPSS manual (1975) provides a general discussion on regression analysis. The formulation of computer-derived solutions in terms of matrices are found in such texts as Ezekiel and Fox (1959), Johnson and Leone (1964), Rao (1973), and Yamene (1973).

Multiple linear regression is a general statistical technique which obtains the "best fitting" linear relationship between a dependent variable and a set of independent variables, and evaluates the contribution of each independent variable to this linear relationship while controlling for the effect of the other independent variables. In the standard multiple regression equation, the best fit is obtained by using the method of least-squares to minimize the squared deviations from the regression equation. Although the technique may be used for predictive or explanatory purposes, in the context of this analysis it is used as a tool for the evaluation of covariation in home-based work trips in

Edmonton and variables considered to be associated with work trip-making behaviour. Consequently, the emphasis is on the individual regression coefficients and establishing significant relationships.

In this study the multiple linear regression technique is adequate for investigating the characteristics of the relatively simple type of relationships expected between the dependent variable and each independent variable and for experimenting with any reasonable combination of independent variables. When variables seem to be non-contributory, they are removed in the next regression which then uses only the significant variables. In this way, ideas are tested until only statistically significant coefficients are obtained. Regression analysis has the advantage of being easily performed, especially with the use of electronic computers. The SPSS multiple linear regression package which is readily available in the Amdahl 470 computer at the University of Alberta, is used in this analysis.

2.6 ASSUMPTIONS OF MULTIPLE REGRESSION ANALYSIS

The multiple linear regression model is based on the following set of assumptions.

1. The sample is drawn at random.
2. Each value of X_i and of Y is obtained without measurement error.
3. The overall frequency distributions of both the dependent variable and the independent variables are normal.
4. The variance of the Y values about the regression line must be the same for all magnitudes of the independent variables. This is the assumption of homoscedasticity.
5. The relationship between the dependent variable Y and the independent variables X_i is linear.

6. The independent variables X_i are linearly independent of each other.

The extent to which geographers and other researchers have shown awareness of these assumptions of the multiple linear regression model, and the apparent deficiencies both in the discussions and in actual empirical application of the model have been discussed by Colenutt (1968), King (1969), and Poole and O'Farrel (1971). There are few explicit references to the assumption that the sample is drawn at random and that there is no measurement error in the data because in most cases these are taken for granted. The assumption of normality is often difficult to satisfy and Gould (1970) has noted that when variables are transformed to achieve normality, the actual form of the relationships observed, and thus the model, become much more difficult to interprete. Although Berry and Barnum (1962) perform logarithmic transformations to achieve greater homoscedasticity, this assumption has not been given much attention and Quarmby (1967) observes that there is nothing to indicate how accurate or inaccurate are the obtained results when the assumption of homoscedasticity is not strictly met. The assumption of linearity is recognized by most geographers discussing the use of the regression model, and since the linear form of the function may not always be the best, several forms of transformation have been used. Hagget (1965) suggests the use of polynomials when the linearity assumption cannot be satisfied even by transformation. The assumption of the relative independence of the independent variables is widely recognized too, since most researchers have examined their correlation matrices in order to ensure that the variables are independent and that there is no evidence of multi-collinearity. This is because if this assumption is not met, it leads to serious problems such as imprecise estimation of regression coefficients,

possible reduction in their absolute values, and instability of the results obtained. Blalock (1963) notes some of the practical implications of correlated independent variables for social research. Although a number of alternative techniques may be applied to specific empirical problems to make the regression model valid, when the fundamental assumptions are not satisfied, there is no accepted preferable approach.

Since the work trips in Edmonton were systematically aggregated according to major destinations in the city, the samples were not drawn at random. Due to the way in which the data was obtained, it is very difficult to check for any measurement error in the data. Most of the variables are not normally distributed and the assumption of homoscedasticity is not tested for. The assumed linear relationship between the dependent variable and the independent variables is investigated. The assumption of the relative independence of the independent variables is ensured by examination of the correlation matrices and systematically removing correlated independent variables until the best explanatory equation is obtained. Therefore, despite the invalidity of the data on some of these assumptions, regression analysis is employed. The variabiles used in the analysis are described in the following section.

2.7 VARIABLES USED IN THE ANALYSIS

(a) Dependent Variable

1. Total Trips (T_{ij}): - The number of trips which is used as a measure of travel demand is treated as the dependent variable. It is an interaction term which measures the number of work trips from an origin zone to a destination zone.

(b) Independent Variables

1. The number of trips originating in a zone (O_i): - This is a measure of a zone as a work trip producer since it shows the number of workers resident in zone i. It is expected to be positively related to total flow or interaction between pairs of zones (T_{ij}) since the more work trips a zone produces, the more trips it can afford to send to major employment centers. Wilson (1971) uses this variable as a mass term associated with zone i in his spatial interaction model and in our model of the journey to work it is used in the same way as an explanatory variable.

2. The number of trips attracted to a zone (D_j): - This is a measure of a zone as a work trip attractor since it shows the total number of work trip opportunities or jobs available in a zone. It is also expected to be positively related to total flow or interaction (T_{ij}) since the more jobs there are in a zone the greater is the number of workers attracted to that zone. Wilson (1971) also uses this variable as a mass term associated with zone j in his spatial interaction models and in our model of the journey to work, it is used in the same way as explanatory variable.

These two variables, the number of trips originating in a zone (O_i) and the number of trips attracted to a zone (D_j) are trip ends and are therefore major explanatory variables in trip distribution models. The total of each of them is expected to be equal to the total volume of work trips on all links within the region since $\sum_j T_{ij} = O_i$ and $\sum_i T_{ij} = D_j$. It is expected however, that the importance of these two distributional variables may be modified by other important variables related to tripmaking.

3. Automobile Ownership (AUTO): This is a commonly used variable in travel demand models and it is expected to vary directly with travel demand. Its use is usually justified on the grounds that it is regarded as a proxy for the income variable. Lave (1968) notes that although automobile ownership is believed to have a high correlation with income, this relationship is not stable. Also, it has been argued that peoples perception of automobile costs indicate that they are not purchased for commuting reasons only but also for their social utility. It has therefore been suggested that the effect of automobile ownership should be measured with great care so that it does not constitute a major source of bias. In our models, the car ownership variable used is the ratio of cars per person for each zone.

4. Parking Cost at Destination (PCOST): - It seems likely that the relative cost of alternative transportation modes will influence the commuter's modal choice decision and that other things being equal, the cheaper mode should be preferred. However, parking cost at destination may be expected to limit the number of work trips that can be made by car even if a car is available and the income is favourable and the higher the parking cost the fewer the number of work trips by automobile to that destination. In Edmonton, the highest parking costs are found in the Central Business District and in the University of Alberta.

Parking cost at destination is the only cost data for automobile available and although it may increase the cost of travelling by automobile considerably, no measure of the relative cost of travelling by automobile and by transit is used in this study. A public transit fare is paid directly in cash and is obviously associated with a par-

ticular journey. In Edmonton in 1971, it cost 25 cents to travel by transit to any part of the city, including transfers. There is also a system of bus pass of $10.00 per month which is cheaper for regular bus users. Therefore, whereas the low cost of public transportation is uniform all over the city, automobile cost is a function of distance and we examine the importance of this variable.

5. Distance (DIST): - Distance is an important measure of spatial separation used in travel demand models. It is expected to be inversely related to travel demand. Warner (1962) uses the distance variable but Lave (1968) does not see any reason why the distance variable should be used separately, since most of its side effects have been incorporated through the time and cost variables, and he used a form of the comfort variable in which distance is entered multiplicatively.

Also, since time is a function of distance, it has been argued that the use of both distance and time as independent variables in the same regression is a potential source of multi-collinearity. In our models, both variables are used in the regressions but only one of them is used in any one run in order to control for collinearity between these measures of spatial separation.

6. Weighted Travel Time (W TTIME): - Travel time is a function of distance and is a measure of spatial separation between zones. It is an important measure of transport system characteristics by different modes. Like distance, it is generally considered to be inversely related to tripmaking and is used in most studies of travel demand. Warner (1962), Lisco (1967) and Quarmby (1967), use travel time in their studies of travel demand and Beesely (1965) and Oort (1969) discuss the value of travel time to commuters.

Although the major components of the time spent in travelling consists of the in-vehicle travel time and the excess travel time, it is more appropriate to use the door-to-door travel time since most people view a journey primarily in this way. The door-to-door travel time by automobile and by transit are used in obtaining the weighted travel time.

7. Accessibility Indices: - Accessibility of a zone to the transit system is important in trip distribution. It affects the number of work trips by transit which a zone can send to major employment centers. A number of variables, namely, choice modal split (CHOICE MSPLIT), total modal split (TOTAL MSPLIT) and automobile captive modal split (AUTOCAP MSPLIT) are used to assess the accessibility characteristics of the zones.

8. Residential Density: - The residential density characteristics of the zones affect the work trip generating capacities of the zones. The proportion of residential land in each zone with low density, medium density and high density housing-LOW RES, MED RES and HIGH RES respectively is expected to be significantly related to the number of work trips originating in each zone and possibly the destinations of the destinations of these trips.

The exact definition and the sources of these variables are discussed in Chapter IV. Before this, a general description of transportation in Edmonton is presented in Chapter III.

CHAPTER III

THE EDMONTON INFRASTRUCTURE AND PREVIOUS STUDIES

3.1 GENERAL DESCRIPTION

Edmonton, located on the Western Canadian prairies, is the capital of the Province of Alberta. It has undergone rapid growth since World War II and its population of 438,425 persons in 1971, indicates an increase of over 30 percent since 1961 (Statistics Canada). Due to its substantial increase in population the city has expanded in size to cover an area of 121 square miles (309.76 square kilometers).

Like many other prairie cities, the original street pattern is a rectangular grid and this is found mainly in the central area and in the older residential districts. Recent outlying residential districts, designed as neighbourhood units, exhibit a more curvelinear street pattern. Superimposed on all these are some major arterial highways that cut across the city.

The city is bisected by the North Saskatchewan River consequently, the flow of traffic between the north and south sides of the city is constricted and channelized only at several points made possible by the nine bridges of varying sizes and capacities linking the north and south sides of Edmonton. Therefore the physical structure of the city and its road pattern strongly influence traffic and transit circulation within the city.

In 1971, 151,125 persons or 35 percent of the total population of Edmonton were employed. Table 1 shows that although the absolute number of people employed in the Central Business District increased between 1961 and 1971 the percentage of the city's population employed

TABLE 1: EMPLOYMENT AND MODAL SPLIT FOR WORK TRIPS
TO THE CENTRAL BUSINESS DISTRICT
1961-1971

CIVIC CENSUS RESULTS FOR THE CITY				
YEAR	1961	1964	1967	1971
POPULATION	300,000	343,465	393,205	435,293
TOTAL EMPLOYMENT	93,500	108,000	125,000	151,125
% EMPLOYMENT OF POPULATION	31%	31%	32%	35%
CENTRAL BUSINESS DISTRICT EMPLOYMENT				
C.B.D. TOTAL EMPLOYMENT	21,200	21,600	22,000	26,100
% of C.B.D. EMPLOYMENT OF TOTAL EMPLOYMENT IN THE CITY	23%	20%	18%	17%
EMPLOYEES BY CAR	11,700 (55%)	12,000 (56%)	12,100 (55%)	13,000 (50%)
EMPLOYEES BY BUS	7,200 (34%)	8,700 (40%)	8,400 (38%)	11,400 (44%)
PEAK HOUR TRAVEL (7:30-8:30 am)				
C.B.D. TOTAL	-	11,000	12,200	15,200
BY CAR	-	6,480	7,300	8,150
BY BUS	-	3,860 (35%)	4,170 (34%)	6,250 (41%)

Source: Bakker J.J., and Clement T.O., Transit Trends in Edmonton. Paper prepared for the Annual Meeting of the Roads and Transport Association of Canada, September 1974, Toronto, Ontario, Canada.

in this area decreased over the same period. The decrease in the percentage of work trips to this central area may be attributed to changes that have taken place in Edmonton in recent years some of which Plunkett (1972) has described. These changes include the decentralization of the Central Business District functions and the dispersed location of regional shopping centers, leaving the district with only specialized functions and office employment. The transportation system characteristics and the spatial distribution of workers and other job opportunities in the city are examined in greater detail below.

3.2 TRANSPORTATION SYSTEM CHARACTERISTICS

(a) Transit Ridership in Edmonton

Since the end of World War II, the transit system had been faced with the problem of expanding its facilities in order to accommodate the rapidly growing population of the city. Under these circumstances, it was fairly profitable and sound up to 1954, when the revenue was 104.9 percent of the cost.

After 1954, however, in spite of a generally expanded bus system and an increased number of bus miles covered, the percentage of the cost obtained from the revenue declined steadily (Table 2). This may partially be due to the fact that the benefits of extending bus services take a long time to be fully realized. Another major factor could be an increased consideration of transit as a public service which is not expected to meet all its costs from the fare box. Therefore, despite the decreasing ability of the system to pay for itself, it was being constantly improved.

Although transit vehicles presently operate on a route

TABLE 2: TRANSIT OPERATING STATISTICS FOR EDMONTON

(1951-1974)

YEAR	BUS MILES COVERED	TOTAL COSTS (IN $'s)	TOTAL REVENUE (IN $'s)	% OF COST FROM REVENUE
1951	4,700,000	2,700,000	2,700,000	100
1952	5,140,222	3,067,123	2,922,037	95.3
1953	5,105,903	3,053,060	3,193,466	104.6
1954	5,140,955	3,122,167	3,276,815	104.9
1955	5,223,359	3,230,701	3,188,859	98.7
1956	5,486,816	3,364,838	3,185,756	94.7
1957	5,616,641	3,483,196	3,254,977	93.4
1958	5,757,133	3,694,241	3,657,077	99.5
1959	5,757,092	3,799,974	3,700,941	97.1
1960	5,651,432	3,720,027	3,486,970	93.7
1961	5,741,427	3,905,395	3,397,038	86.9
1962	6,180,021	4,146,348	3,825,661	92.3
1963	6,614,350	4,377,538	3,841,089	87.7
1964	7,121,169	4,773,495	3,984,965	83.5
1965	7,564,279	5,378,097	4,421,908	82.2
1966	7,700,846	5,869,470	4,777,932	81.4
1967	7,909,740	6,639,598	5,152,879	77.6
1968	7,941,128	7,696,921	6,873,026	89.3
1969	7,811,967	8,272,363	7,143,688	86.4
1970	8,322,345	9,005,701	7,694,287	85.4
1971	8,533,228	9,984,559	8,030,765	80.4
1972	9,034,454	11,100,533	8,794,910	79.2
1973	9,205,513	11,872,179	9,049,702	76.2
1974	10,200,100	14,615,000	10,477,525	71.7

SOURCE: EDMONTON TRANSIT SYSTEM, MONTHLY OPERATING STATEMENT

network which is superimposed on the city's grid street pattern so that private automobiles and transit vehicles share the same road network (Figure 1), more and more bus lanes are introduced in order to facilitate transit service. Conversion from the trolley fleet to motor buses has resulted in there being only 80 trolley buses out of the 420 vehicle rolling stock of the Edmonton Transit System in 1975. Light Rapid Transit is being developed for the city with an initial portion of this which is now under construction expected to be completed in 1978.[1]

The Metropolitan Edmonton Transportation Study (METS) notes that a combination of declining ridership and increasing population has resulted in a substantial decline in per capita ridership between 1946 and 1961.[2] Since 1964 however, absolute ridership has risen steadily and rides per capita have been rising since 1969 (Figure 2). This trend constrasts sharply with the trend observed in the U.S.A. by Beier (1972) where ridership on motor buses declined by 13 percent, and where, in fact, the number of operating bus companies declined by 11 percent between 1960 and 1968. Table 3 shows that Edmonton has a fairly favourable number of rides per capita in comparison with some other cities in Canada and with cities of roughly the same population in the United States.

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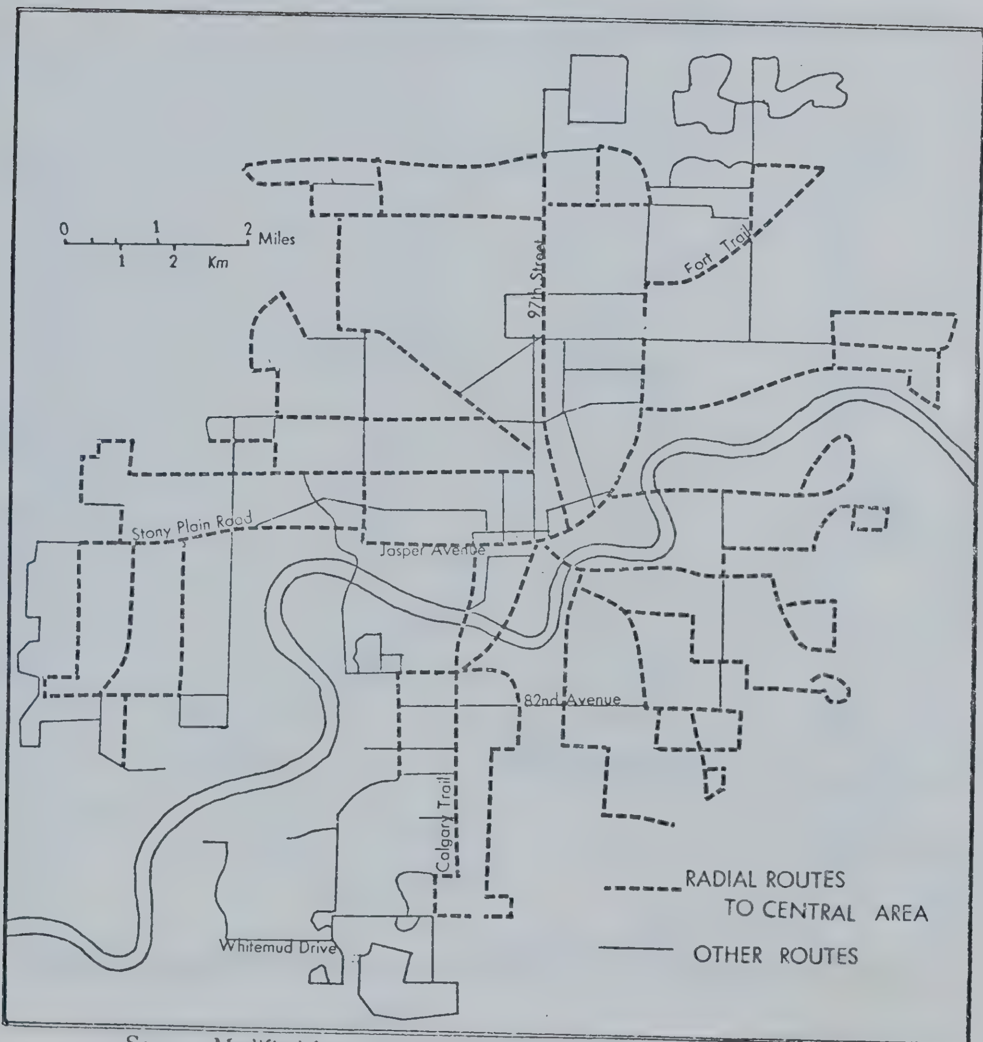
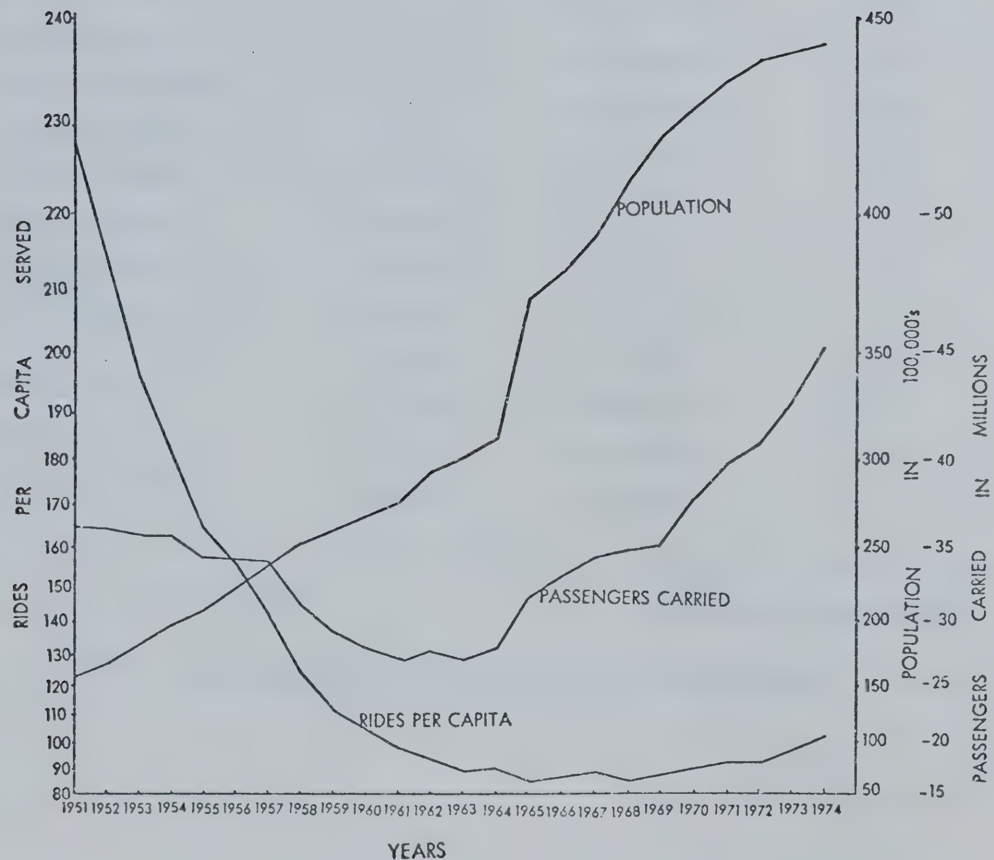
1. Bakker J. J., and Palmer, M. F. "Operating Strategies for Bus Transit in Edmonton." Abstract of a paper presented at the Annual Conference for Roads and Transportation Association of Canada, at Calgary, September 22 - 25, 1975.

2. Metropolitan Edmonton Study Report, 1963.



Source: Modified from Edmonton Transit System Bus Route Schedules for 1971.

FIG. 1 EDMONTON TRANSIT ROUTES IN 1971



Source: Edmonton Transit System, Monthly Operating Statement.

FIG. 2 TREND OF TRANSIT RIDING IN EDMONTON (1951-1974)

TABLE 3: RIDES PER CAPITA ON TRANSIT FOR SOME MAJOR CITIES OF CANADA AND U.S.A.

CITY	POPULATION	REVENUE PASSENGERS CARRIED IN 1974	RIDES PER CAPITA
TORONTO (ONTARIO)	2,628,043 *	329,796,000	126
WINNIPEG (MANITOBA)	540,262 *	62,001,000	115
EDMONTON (ALBERTA)	438,152 +	45,200,000	102
MONTREAL (QUEBEC)	2,743,208 *	269,119,000	96
CALGARY (ALBERTA)	403,319 +	33,434,000	83
LONDON (ONTARIO)	223,222 +	16,944,000	76
HALIFAX (NOVA SCOTIA)	222,637 *	11,449,000	51
MINNEAPOLIS (MINN.)	434,400 +	56,514,000	130
ATLANTA (GA)	497,421 +	58,600,000	118
BUFFALO (N.Y.)	462,768 +	31,458,000	68
CINCINNATI (OHIO)	451,455 +	25,459,000	56

+ CITY POPULATION

* METROPOLITAN POPULATION

SOURCE: MONTHLY TRANSIT TRAFFIC. (AMERICAN PUBLIC TRANSIT ASSOCIATION) NO. 1, JANUARY, 1975.

(b) Automobile Ownership

Like other major cities, Edmonton has experienced an increased automobile ownership in recent years. The average car ownership ratio in the city in 1951 was 5.3 persons per car but in 1961 it had risen to 3.7 persons per car and in 1971 it was 3.4 persons per car. Though the rate of increase had declined, it is possible that the number of cars in circulation in the future will continue to increase due to increasing income levels and the demand for better living.

It has been observed that the higher automobile ownership has been accompanied by a slightly lower automobile occupancy in Edmonton, as the average peak hour occupancy rate for work trips was 1.21 in 1961 and had decreased to only 1.16 in 1971.[3] Therefore, if this decrease in the number of persons carried by an average car, is not attributed to increase in transit riding, the fear is that more automobiles will be in circulation in future to accommodate equal number of people.

It may be felt that the cost of parking at the destination may prevent certain trips, especially work trips, to be made by automobiles even if it is available. The Central Business District and the University of Alberta had the highest parking costs (exceeding $10.00 a month) in the city in 1971, but surprisingly this did not decrease the volume of work trips to these major destinations substantially. In fact, it was found that parking cost at destination is not a strong detterent to work tripmaking to major employment centers in the city.

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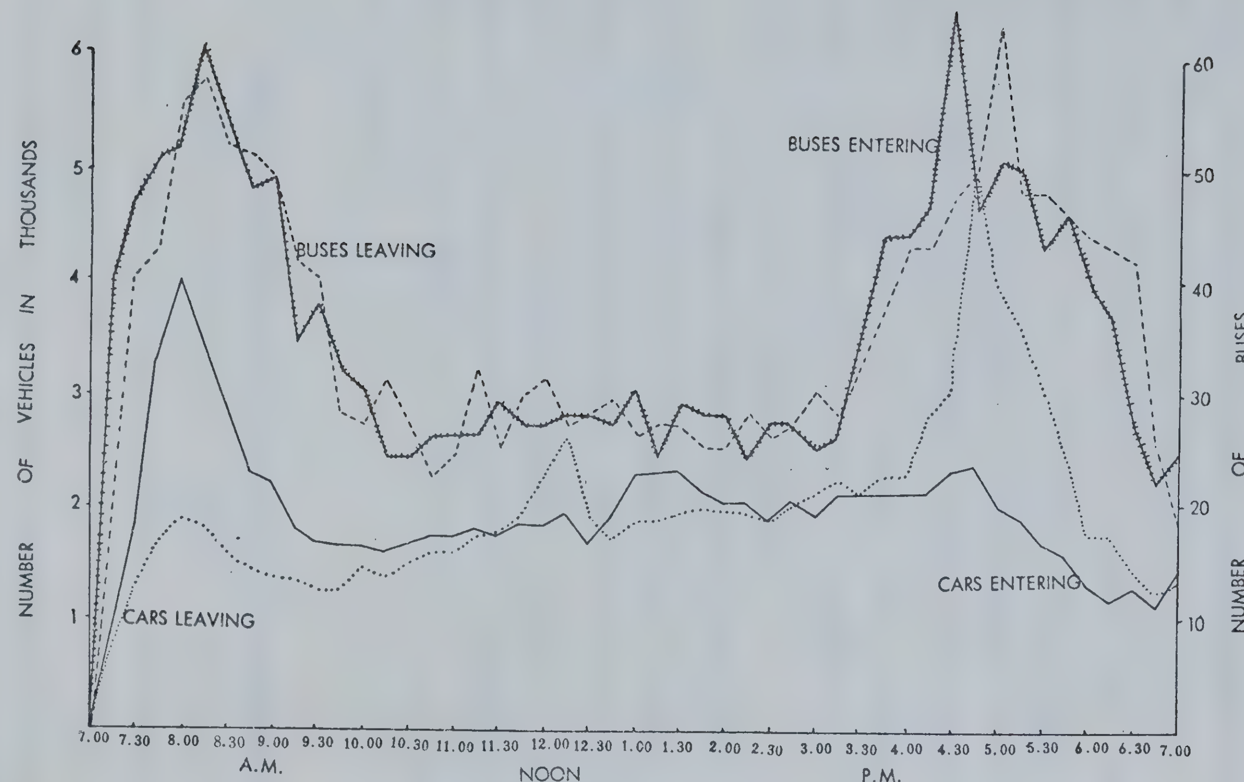
3. Clement T. O., "Some Preliminary Observations on Peak Hour Choice Modal Split in Edmonton (1971)."

(c) Travel Peaks in Edmonton

One of the major characteristics of urban transportation is that it moves in two sharp peaks, one in the morning and the other in late afternoon on work days, during which the transportation system is taxed heavily. Figure 3 illustrates the pronounced peaking of transit trips in both absolute terms and relative to the automobile, for trips entering and leaving the Central Business District of Edmonton in 1972. The two major peaks reflect the concentration of home-to-work trips in the morning and the work-to-home trips in the late afternoon, while the secondary peaks in-between reflect either shopping trips, business trips or workers going home for lunch. These peaks, observed in a number of other cities, in United States by Meyer, Kain and Wohl (1959) are indicative of how work trips usually strain the capacity of the transportation system during the peak hours.

Even though it has been realized that a planned program of staggered working hours would enable the same total travel to be accommodated over a longer period and thus reduce the problem of extreme peaks for urban transportation, no such program has been implemented in Edmonton. This research is therefore concerned primarily with the explanation of the pattern of work trips to major employment centers in the city because the concentration of work trips in time and space make them the major cause of traffic congestion in Edmonton. Moreover, it is generally agreed that a highway or transit system adequate to deal with work trips will have more than enough capacity to deal with shopping, business, social and recreational trips.



Source: Engineering and Transportation Department, Studies and Research Section.

FIG. 3 TRANSIT AND AUTOMOBILE VEHICLES PASSING THROUGH THE CENTRAL BUSINESS DISTRICT OF EDMONTON IN 1972

(d) Travel Time by Transit and by Automobile

The distances which can be covered in Edmonton in travelling by bus or by automobile during the morning peak hour (7:30 a.m. - 8:30 a.m.) from Zone 0014 in the Central Business District to other parts of the city are presented graphically in Figures 4 - 7. Figures 4 and 5 show that whereas the actual time spent in the vehicle in travelling from this zone to the outskirts of the developed parts of the city in 1971 by automobile was 15 minutes, it would take between 20 and 35 minutes when the same journey is made by bus. When door-to-door travel times are considered (Figures 6 and 7) the difference in travel time between the two modes is more pronounced.

This observed difference in time between travel by transit and travel by the automobile is suggested as an important factor to be taken into consideration in the choice of mode in the city. It is also suggested that it would not be adequate if efforts to improve transit patronage in the city are directed towards reducing the transit in-vehicle time, since this component of transit travel is very similar to that of the automobile.

3.3 PREVIOUS ANALYSES RELATED TO WORK TRIPS CONDUCTED IN EDMONTON

Three previous analyses related to work trips have been conducted in Edmonton. The first analysis is the Metropolitan Edmonton Transportation Study (METS, 1963) conducted by the Edmonton Regional Planning Commission. The second is an unpublished M. Sc. thesis, An Investigation into the Modal Split Relationships in the City of Edmonton, by Rhyason (1967). The third is also an unpublished M. A. thesis, Central Business District Employment in Edmonton 1961-1967, by Plunkett (1972).

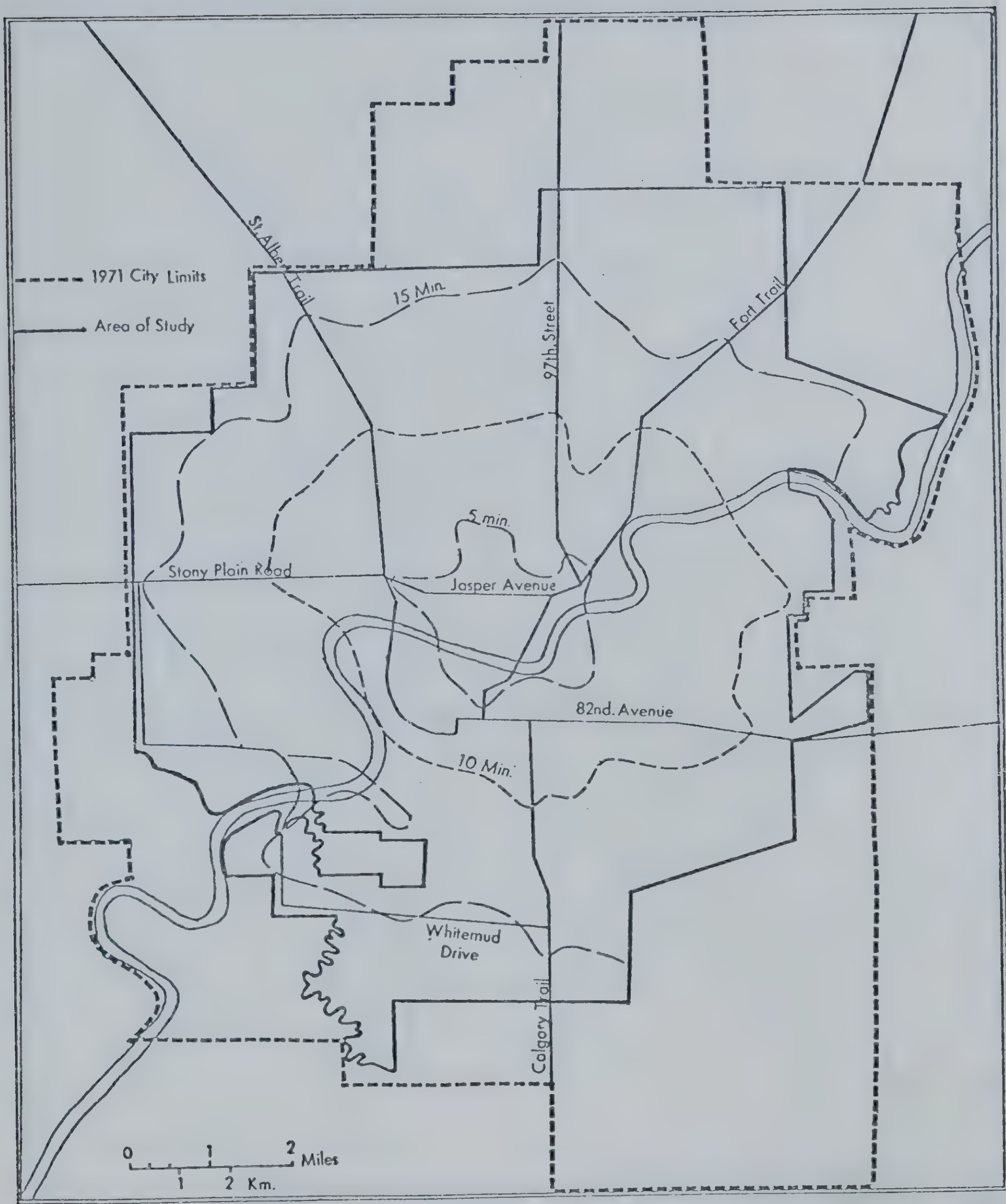


FIG. 4 AUTOMOBILE IN-VEHICLE TRAVEL TIME ISOCHRONE 1971

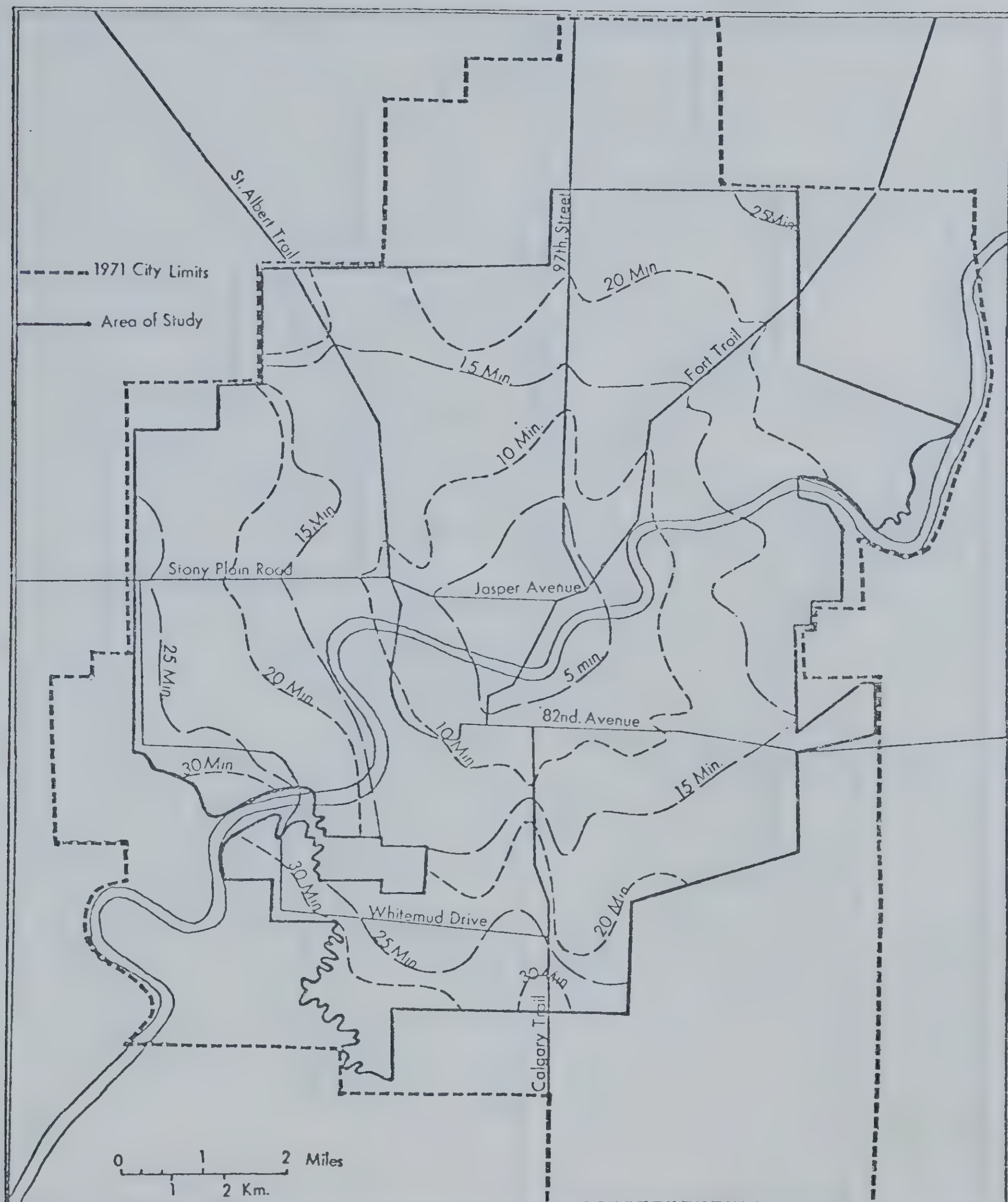


FIG. 5 TRANSIT IN-VEHICLE TRAVEL TIME ISOCHRONE 1971

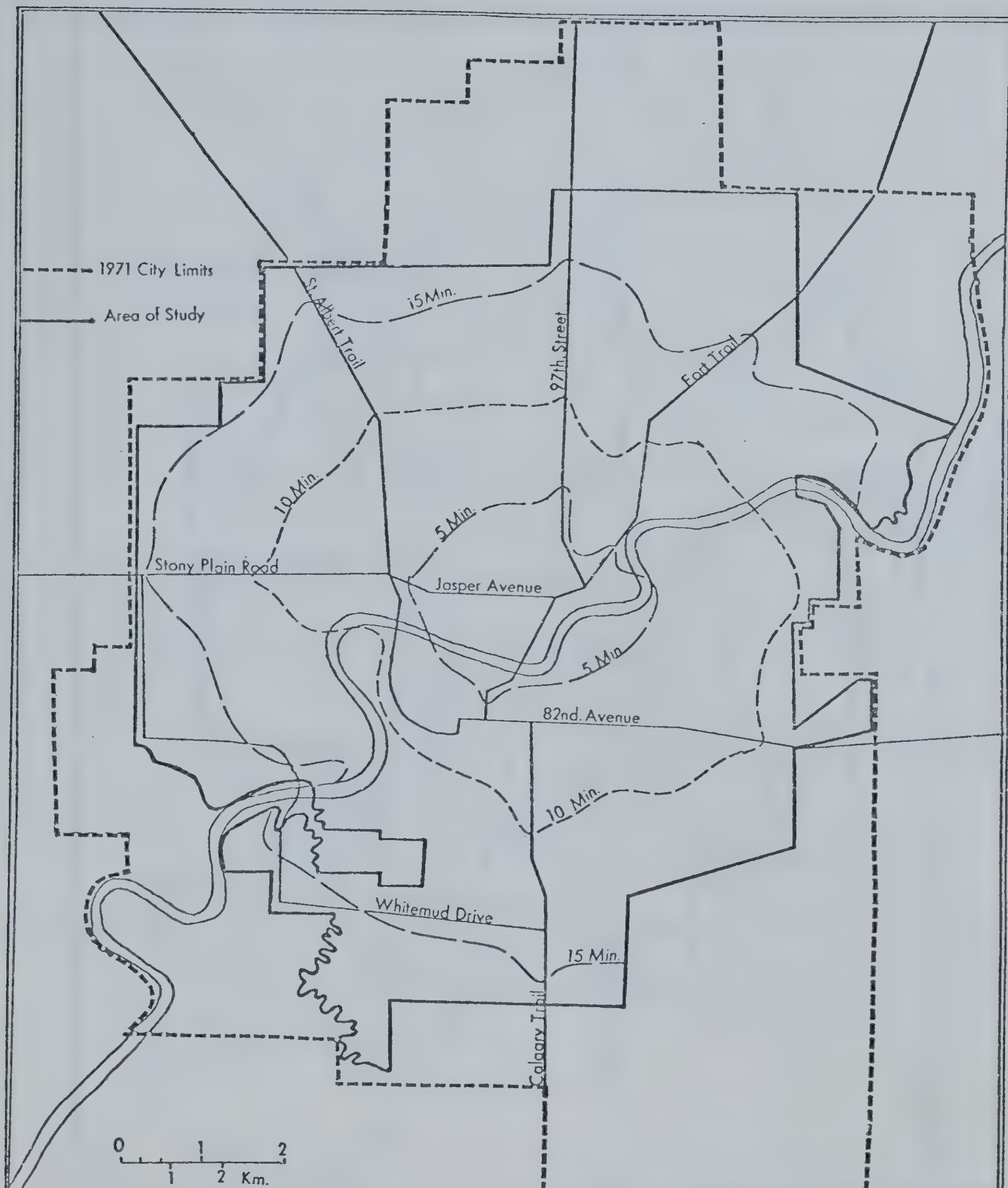


FIG. 6 AUTOMOBILE TOTAL TRAVEL TIME ISOCHRONE 1971

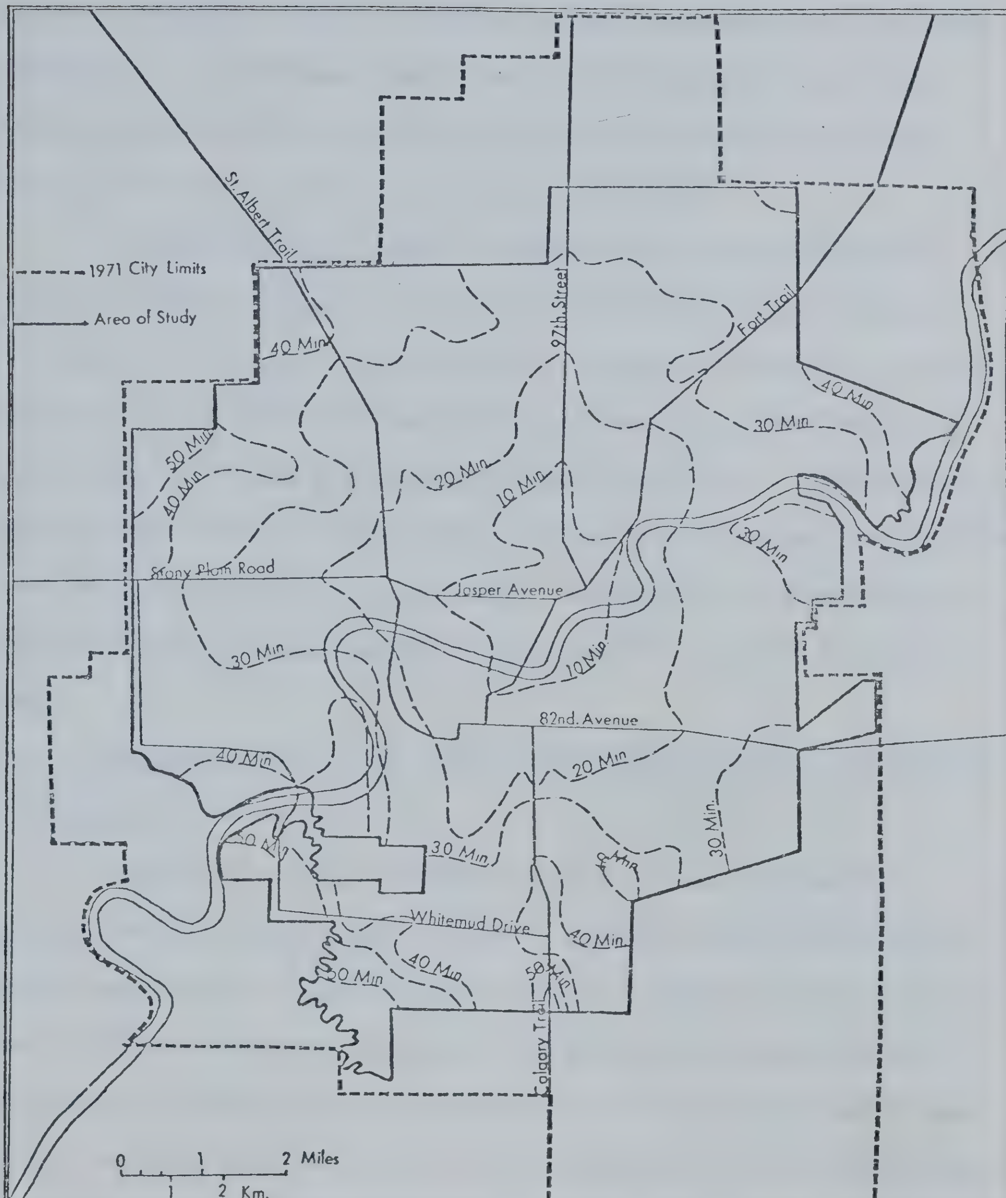


FIG. 7 TRANSIT TOTAL TRAVEL TIME ISOCHRONE 1971

(a) <u>The Metropolitan Edmonton Transportation Study (METS, 1963)</u>

The METS was based on the need for a transportation plan for Edmonton, which would take its future growth and development into consideration. It used census data, home interviews, truck and transit questionnaires and land use data, all tabulated according to census tracts, as well as external origin-destination data.

The Metropolitan Edmonton Transportation Study considered different types of trips (including work trips) by different modes. It notes that the central area attracts the highest proportion of total employment in the city and that work trips constitute 37.4 percent of total trips within the Metropolitan Study Area in 1961. The METS report also observes that the use of public transit for work trips to the central area during the morning peak hour show a consistent trend of decline both absolutely and relatively for zones further away from the city center.

(b) <u>An Investigation into the Modal Split Relationships in the City of Edmonton</u>

Rhyason used data obtained in 1961 for the Metropolitan Edmonton Transportation Study as well as data from origin-destination surveys conducted in conjunction with the civic census in 1961 and 1964. Although primarily concerned with examining the major factors affecting the choice of mode for home-to-work journies destined to the Central Business District, he also investigates if there was the possibility of employment changes being associated with modal choice within the district. He observes a decrease in Central Business District employees in the inner districts and an increase in the outer districts which he attributes to these outer districts proximity to developing

industrial areas.

(c) Central Business Employment in Edmonton 1961-1967

Plunkett used the data on Central Business District population and employment as summarized by Rhyason, as well as parking and traffic conjestion data obtained from the Traffic Engineering Department. He obtained the information on the distribution and numbers of functions in the Central Business District for 1961 and 1967 from Henderson's Directory. These were supplemented by data obtained from field work and zoning registration map.

He investigates the spatial distribution of the residential location of Central Business District employees within the city with an aim of identifying any relationships between Central Business District proximity and incidence of employment in the district. He also examines the major differences in employment change from zone to zone within the Central Business District from 1961 to 1967.

He notes that the decreasing number of functions, the increasing number of vehicles and shortage of employee parking stalls are significantly related to the decreasing number of employees in the Central Business District over the period. His analysis show that each zone within the Central Business District is characterized by its own problems and individuality which affect the pattern of changes in its employment in different ways over the period.

He observes that the spatial distribution of the residences of Central Business District employees indicate that two well defined areas in the north and south sides of the North Saskatchewan River have an employment structure such that between twenty and thirty percent of their employees work in the Central Business District. He further

observes that, on the contrary, two other major areas located in the north east and south east parts of the city and both of which are situated near other employment opportunities have employment structure such that less than twenty percent of their employees work in the Central Business District.

3.4 THE RELEVANCE OF THE RESEARCH

A major limitation of the previous analyses related to work trips in Edmonton is that they consider mostly the trips to the Central Business District, ignoring other employment centers in the city like the University of Alberta, and the industrial zones in different parts of the city. This may partly be due to the fact that the Central Business District is the largest single attractor of work trips in the city and also partly due to data limitations.

However, major changes in population, employment, land use pattern and transportation system characteristics have occurred within the city since these analyses were made. There has been a considerable increase in the number of regional shopping centers, industries and other establishments located within the surburbs in recent years in Edmonton and these may give rise to a different pattern of traffic flow.

Although some of the previous analyses considered the trend of employment in the Central Business District over a period of time, there has not been any study of factors underlying the pattern of work trips to different employment centers in the city for the same time period. Such a study is necessary in order to deterimine the factors that are significantly related to work tripmaking to different employment centers in Edmonton within a specific period. The empirical work

documented here which deals with work trips in 1971 should help to fill this gap. This study is made possible because of the availability of a fairly comprehensive data on trip interchange and land use characteristics in the city the sources of which are described in Chapter IV.

CHAPTER IV

SOURCES OF DATA AND DEMARCATION OF MAJOR EMPLOYMENT CENTERS

4.1 MAJOR TYPES OF DATA AND THEIR SOURCES

All data used in this study was obtained through the Transportation Planning Branch of the Engineering and Transportation Department in the City of Edmonton. This branch was responsible for the original collection of data on origin-destination survey of home-to-work trips, conducted in November, 1971, in conjunction with the civic census of that year. The land use data originated in the City of Edmonton Planning Department but was obtained in the form it is used in this study from the Transportation Planning Branch of the Engineering and Transportation Department.

The 1971 census used a different questionnaire from that used in previous surveys. Rather than precoding interview cards or manually coding places of work, the Geographically References Data Storage and Retrieval System (GRDSR) was employed. This enabled geocoding to be used for obtaining a great deal of information on trip interchange characteristics in the city. The original processing of this data, which took about three years, was done by the Transportation Planning Branch. No such comprehensive information on trip interchange characteristics were obtained for the city before 1971. The next period for which similar information can be obtained is 1976 and it may take some time to be processed and summarized in a form in which it can be used.

The data was aggregated into various types of geographic sub-areas - METS Zones, METS Districts, Population and Land Use (PLUS) Areas, Population and Land Use (PLUS) Districts, Traffic Districts and Traffic Zones as established by the Engineering and Transportation

Department in 1971. The 234 Traffic Zones within the city limits as delineated by the Transportation Planning Branch, and presented in Figure 8, are used in this study. The Traffic District number is obtained by dropping the low order digit from the Traffic Zone number. The trip interchange data was provided for each origin-destination zone pair in the study area resulting in a large matrix. The land use data was provided for each Traffic Zone. All data obtained are discussed in greater detail below.

(a) Land Use Data

The land use data describes the characteristics of the 234 Traffic Zones in the area of study. They are measured in acres for each zone and consist of the following variables.

1. Low Density Residential Land
2. Medium Density Residential Land
3. High Density Residential Land
4. Commercial Shopping Center Land
5. Commercial Strip Development Land
6. Commercial Highway Strip Development Land
7. Central Area Office/Commercial Land
8. Government/Institutional Land
9. University/College Land
10. Total Industrial Land
11. Recreational/Argicultural Land
12. Vacant Urban Land
13. Other Classified Land
14. Total Classified Land.

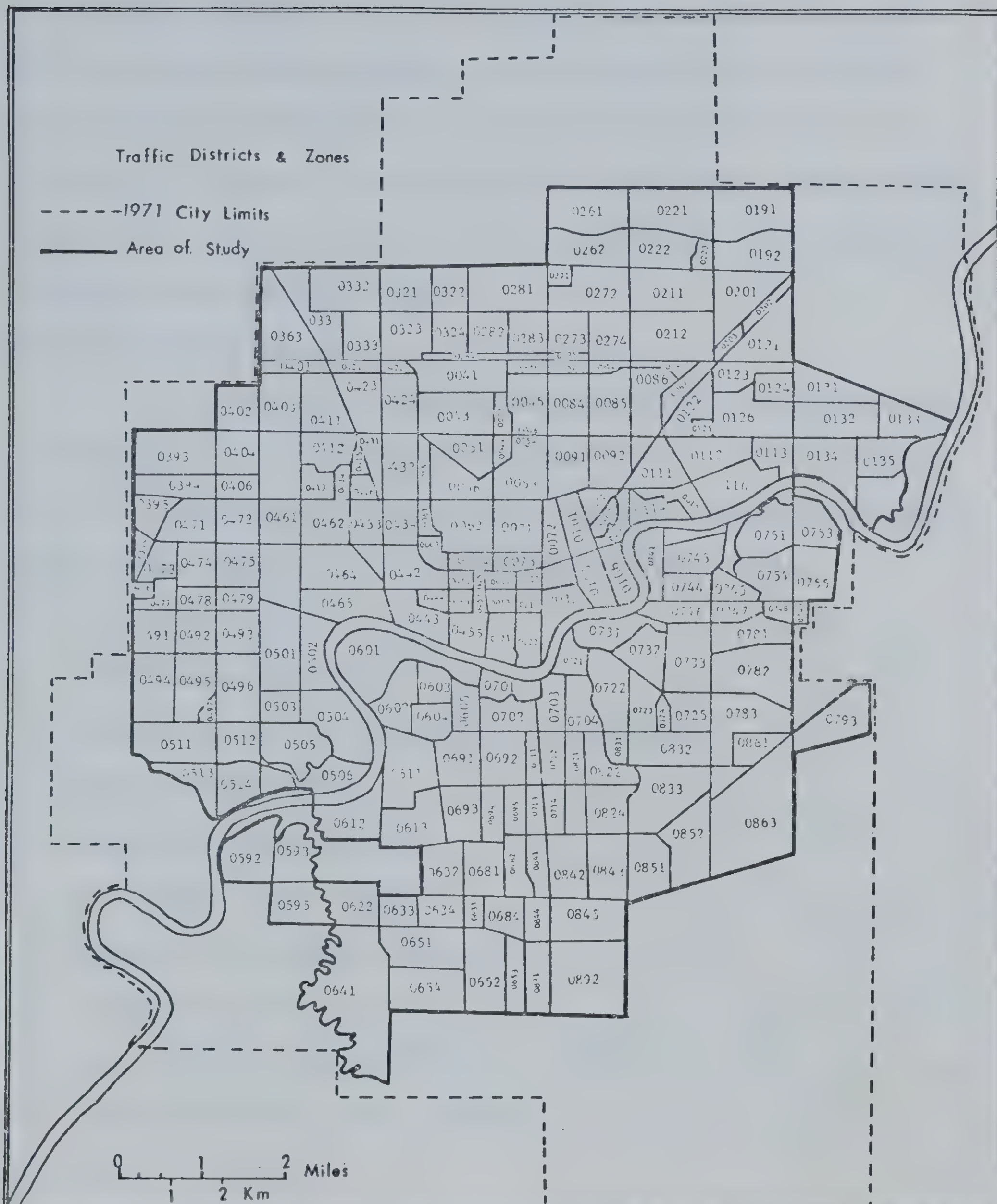


FIG. 8 TRAFFIC ZONES IN EDMONTON, 1971

These land use variables were developed by aggregating zoning classifications as described in the City of Edmonton Planning Department General Summary of Land Use Districts which are provided in Appendix I (A). The record layout together with the format for 234 records for each variable corresponding to the same 234 Traffic Zones in the area of study are contained in a file - TPSR: Land Use 1971, made available through the computer of the University of Alberta by the Transportation Planning Branch (Appendix I(A)).

(b) Trip Interchange Data

In order to give access to the data on trip interchange used in this study, the Transportation Planning Branch provided a computer tape file containing this data for the 234 Traffic Zones in the area of study. These variables, as given, consist of the following,

1. Origin Zone Number
2. Destination Zone Number
3. Transit Choice Trips from Origin to Destination
4. Transit Captive Trips
5. Auto-Driver Choice Trips
6. Auto-Driver Captive Trips
7. Fraction by Transit of Choice Trips (3/(3 + 5))
8. Distance in Tenths of a Mile
9. Auto In-Vehicle Time in Tenths of a Minute
10. Transit In-Vehicle Time in Minutes
11. Number of Transfers
12. Wait Time = Half the Headway of First Bus
13. Transfer Time = Half Sum of Headways of Other Buses

14. Excess Transit Distance at Origin in Meters

15. Car Ownership at Origin in Cars per Person

16. Excess Transit Distance at Destination in Meters

17. Excess Auto Distance at Destination in $\frac{1}{100}$ Blocks

18. Parking Cost at Destination in Cents per Month

A description of the record layout together with the format and blocking parameters for these variables on the computer tape are enclosed in Appendix I(B). A brief description of the meaning as well as modifications (if any) of each variable is given below.

Origin Zone Number: This refers to any of the 234 zones in the study area used as an origin.

Destination Zone Number: This refers to any of the 234 zones in the study area used as a destination.

The next five variables are related to the work trips made and are obtained from the zone to zone peak hour (7:30 a.m. to 8:30 a.m.) work trip interchanges between the 234 Traffic Zones in the area of study. This represents an 85 to 90 per cent sample of total peak hour work trips[1], compiled for each mode of transportation.

Transit users were categorized into choice and captive riders according to the following criterion,

> "At the household level, an automobile was first matched to each reported auto driver work trip. Then each reported transit trip was classified as being choice if an additional automobile was available or captive if an automobile was not available.

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1. Personal communication from D. B. Rhyason, Transportation Planning Branch, Engineering and Transportation Department.

> A particular automoible was considered to be available for one transit trip only."[2]

This form of categorization does not adequately consider other possible factors involved in a commuter's modal choice decision such as occasional uses of the car for work and alternate use of the car at home. The criterion assumes that if an automobile is available for use by the transit rider, then that transit rider has a valid driver's license. This method does not exclude the possibility of classifying the wrong transit trip as being choice especially if two or more transit trips originated in a particular household and less than this number of additional cars were available. The car demand ratio, considered by Quarmby (1967) as the ratio of the number of valid driving licences in the household to the number of cars in that household may have been a more appropriate criterion to use.

Automobile drivers were also categorized by taking transit service into consideration. The following criterion was used,

> "If two or less transit trips were made between any pair of traffic zones, then all automobile trips between these two zones were considered to be captive to the automobile."[3]

The use of two transit trips between any two pairs of zones as the cut-off point was considered to be the error level of the survey data (i.e. error due to mis-reporting, mis-recording, mis-interpreting, etc.) This approach can be justified on the ground that the captive automobile tripmakers are usually found in areas that are poorly served by the transit system.

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2. Source: Transportation Planning Branch, Engineering and Transportation Department, City of Edmonton.

3. Source: Transportation Planning Branch, Engineering and Transportation Department, City of Edmonton.

From the two groups of choice tripmakers, namely transit choice tripmakers and automobile choice tripmakers, another variable, the fraction by transit of choice tripmakers (Transit Choice Trips divided by the sum of transit choice trips and automobile choice trips) was obtained. This variable is the choice modal split.

Distance: This refers to the distance from the zone centroid of each traffic zone to the zone centroid of every other traffic zone within the area of study. It is measured in tenths of a mile (sixteenths of a kilometer) along the shortest path in the arterial network.

Automobile In-Vehicle Travel Time: This is the travel time along the shortest path on the arterial street network. It consists of the individual link times determined from volume/capacity/speed algorithm together with delays due to traffic control devices. It is measured in tenths of a minute, for the A.M. peak hour travel time in the city.

Transit In-Vehicle Travel Time: This refers to the shortest path on the transit network and consists of individual link times taken from the transit route schedules. It is measured in minutes, using the A.M. peak hour transit travel time.

Number of Transfers: This indicates the total number of transfers required in order to make a trip by bus.

Transit Wait Time: This is taken as half the headway of the first bus route used on the shortest path. It is measured in minutes, and is for the A.M. peak hour. This definition is considered to be inadequate and it is modified below.

Transit Transfer Time: This is taken as half the sum of the headways of the second and subsequent bus routes used on the shortest path. It is measured in minutes using the A.M. peak hour transit time.

This definition is also considered to be inadequate and is slightly modified for this study.

<u>Excess Transit Distance at Origin</u>: This refers to the transit walk distance at the origin end of the trip. For each trip originating in a particular zone, the grid distance was calculated from the coordinates of the house and coordinates of the closest bus stop to that house. The mean of all these values is used. It is measured in meters.

<u>Car Ownersip at Origin</u>: This is the ratio of the total number of automobiles in a zone to the total population in the zone. It is measured in cars per person.

<u>Excess Transit Distance at Destination</u>: This refers to the transit walk distance at the destination end of the trip. For each trip arriving at a particular zone, the grid distance was calculated from the coordinates of the closest bus stop to that destination. The mean of all these values is used. It is measured in meters.

<u>Excess Automobile Distance at Destination</u>: This refers to the automobile walking distance at the destination end of the trip. For each trip arriving in a particular destination, the walking distance from the car to the final destination was calculated in $\frac{1}{100}$ blocks. The mean of all these values is used.

4.2 AGGREGATION AND MODIFICATION OF DATA

(a) Land Use Variables:

Only the residential land use data is used in the analysis. The total residential land in each zone was obtained by summing up the low, medium and high density residential land in each zone and this was then used for obtaining the following proportions of residential land

in each zone,

1. Proportion of residential land with low density housing (LOW RES).
2. Proportion of residential land with medium density housing (MED RES).
3. Proportion of residential land with high density housing (HIGH RES).

These were obtained by dividing the area of land in each originating zone with low, medium, and high density housing respectively by the total area of residential land in the same zone.

(b) Trip Interchange Data:

Several modifications and aggregation of the trip interchange data were made in order to obtain the following variables,

1. Total trips (T_{ij})
2. Total number of trips originating in a zone (O_i)
3. Total number of trips arriving in a zone (D_j)
4. Total modal split
5. Automobile Captive modal split
6. Total automobile travel time
7. Transit wait time
8. Transit Transfer time
9. Total transit time
10. Weighted travel time

Total Trips (T_{ij}): Total trips was obtained by summing up all the transit choice, transit captive, automobile driver choice and automobile driver captive trips along a link.

Total Number of Trips Originating in a Zone (O_i): This is the sum of all total trips originating in a zone. It is a measure of the number of workers in a zone.

Total Number of Trips Arriving in a Zone (D_j): This is the sum of all trips arriving in a zone from all the other zones within the

study area. It is a measure of the number of job opportunities available in a zone.

Overall Modal Split (TOTAL MSPLIT): The overall modal split is the ratio between the total transit trips and the sum of all total trips along each link, i.e.

$$\text{TOTAL MSPLIT} = \frac{\text{Transit choice trips} + \text{Transit captive trips}}{\text{Transit choice trips} + \text{Transit captive trips} + \text{Automobile driver choice trips} + \text{Automobile driver captive trips}}$$

Autocaptive Modal Split (AUTOCAP MSPLIT): This is the proportion of workers originating in a zone who are captive to the automobile. It is obtained by dividing the automobile captive tripmakers along any link by the total number of workers at the originating zone.

Total Automobile Travel Time: This is the sum of the automobile in-vehicle time and the walking time for the excess automobile distance at the destination, using an average walking time of 3 m.p.h. (80 meters per minute)[4]. This is measured in minutes and was obtained by the use of a computer program.

Transit Wait Time: The definition of this variable given above does not seem plausible with the observed behaviour of tripmakers. Therefore, this variable was made to have an upper limit of 7.30 minutes following Bakker's (1975) indication that in Edmonton a passenger who wants to catch a bus exactly on time at the bus stop would have an average of 7.30 minutes of waiting.

Transit Transfer Time: The definition of this variable given

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4. Clement T. O., "Some Preliminary Observations on Peak Hour Choice Modal Split in Edmonton (1971)."

above is not realistic, especially in light of attempts of the transit system to work transfers into timed schedules on the transit route network. Therefore the variable was made to have an upper limit of 3.5 minutes which is the mean value for this variable for major trip interchanges in the city (interchanges with at least 10 total trip along them).

Total Transit Time: Total transit time is the sum of the transit in-vehicle time, the waiting time, the transfer time, the walking time for the excess transit distance at origin zone and the walking time for the excess transit distance at the destination. These walking times were calculated using an average walking speed of 3 m.p.h. (80 meters per minute). The total transit time is measured in minutes.

Weighted Travel Time: This is the average travel time for one trip between any origin-destination pair. It is calculated by adding transit and automobile travel time for all transit and automobile trips along any link. This sum is then divided by the total number of work trips along the link.

4.3 MAJOR EMPLOYMENT CENTERS

(a) Spatial Distribution of Employees and Employment

Figure 9 shows the spatial pattern of the density of A.M. peak hour work trip origins in the 234 Traffic zones within the city limits in 1971. The density values are obtained by dividing the total number of peak hour work trip origins or employees in a zone by the total classified land in acres in the zone (see Appendix II). The area of highest density located to the north west of the Central Business District can largely be attributed to the building of modern apartments near the center of the city, while

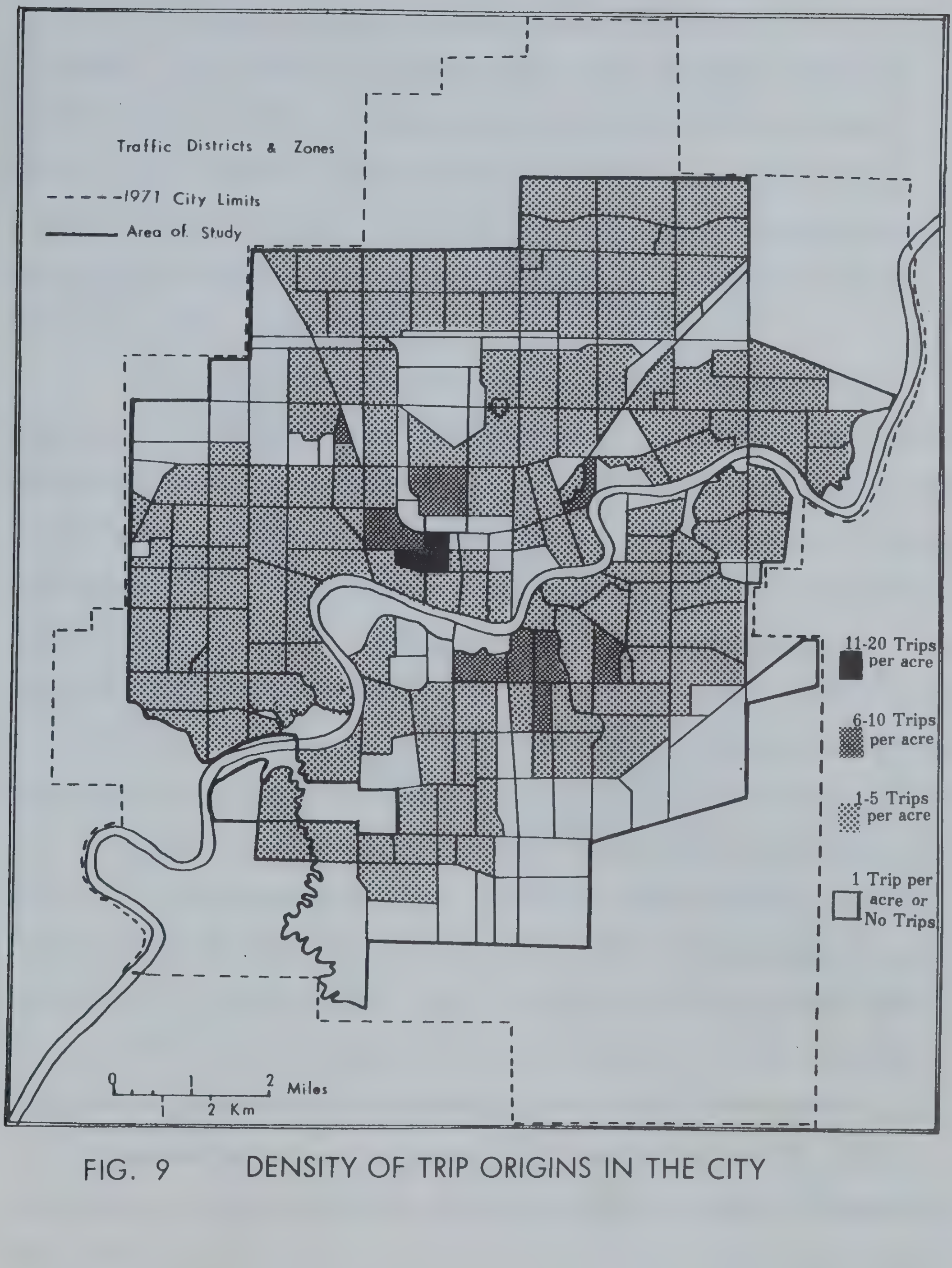

FIG. 9 DENSITY OF TRIP ORIGINS IN THE CITY

the area of high density located in the south side of the North Saskatchewan River is an older residential district. There is no constant trend of decline in the trip densities as distance from the center of the city increases. Clark (1951) has suggested that urban population densities decline exponentially with distance from the center of the city while Newling (1969) views urban population densities as a continuum with a density crater in the Central Business District. Therefore this pattern of residential density distribution in Edmonton is anomalous as has been noted by the METS report in 1961.

Figure 10 shows the spatial pattern of distribution of the density of A.M. peak hour work trip destinations in the city. The density values are obtained by dividing the total number of work trip destinations or employment in a zone by the total classified land in acres in that zone (see Appendix II). The highest concentrations are located in the Central Business District, and the industrial zones lying immediately to the north of the district as well as the University of Alberta. The industrial zones in the periphery of the city fail to be identified by this approach because these zones are larger in size and consequently the resulting densities are low.

There are zones which do not generate or attract any work trips in the city. These comprise the zones containing office buildings, factories or warehouses, the Industrial Airport, industrial corridorswithin the city, the University of Alberta Farm. They also include some zones along the valley of the North Saskatchewan River and the ravines of its tributaries which the city has maintained as parks, public land and open spaces. It is also interesting to note that work trips originating from St. Albert, Sherwood Park, Fort Saskatchewan and other smaller residential communities around Edmonton are not considered because they fall outside the city limits.

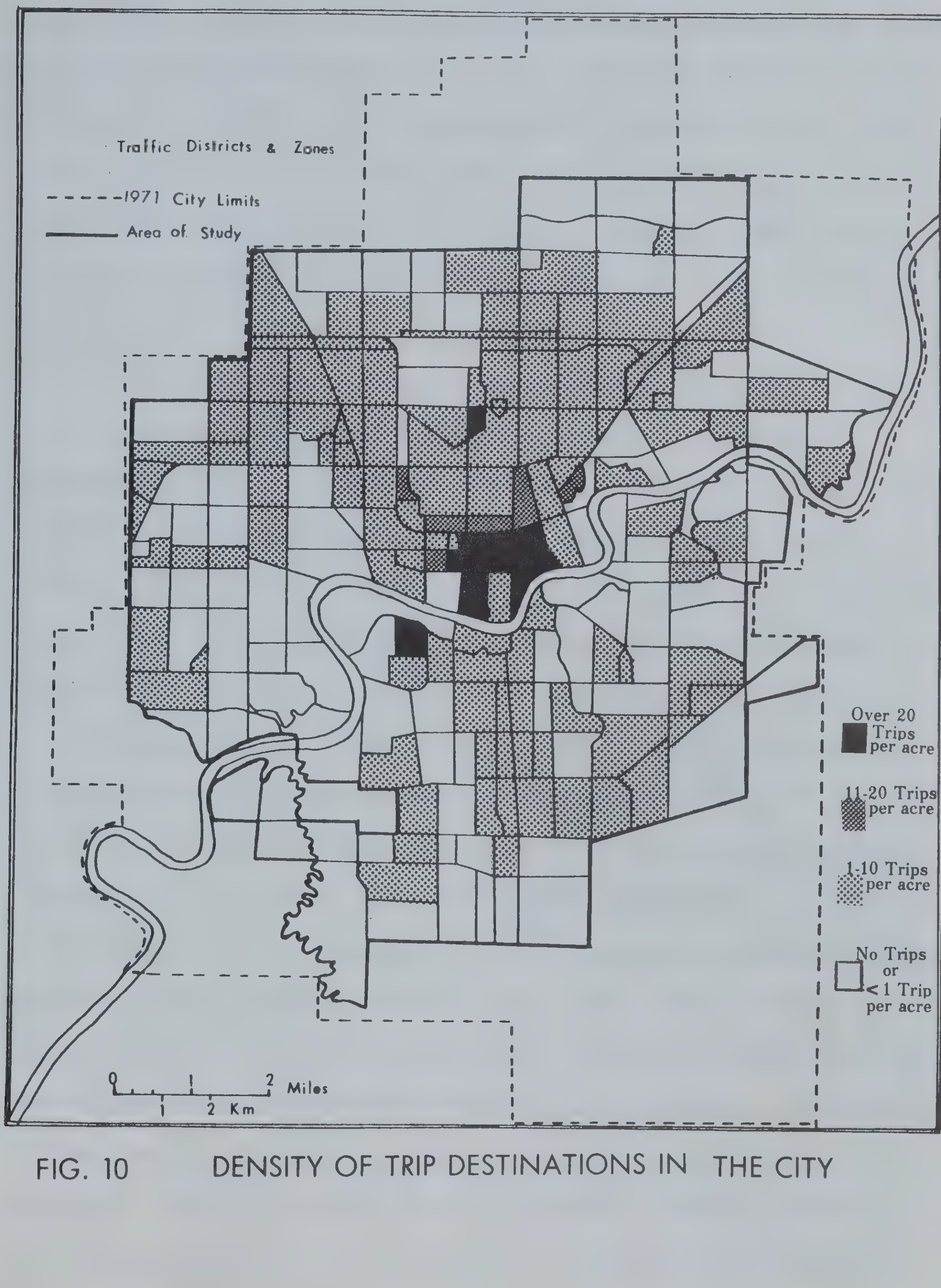

FIG. 10 DENSITY OF TRIP DESTINATIONS IN THE CITY

(b) Sampling Edmonton Work Trips

The 234 traffic zones in the City of Edmonton give rise to a large matrix of 54,756 zone pairs containing 62,542 peak hour work trips and some of the links contain zero trips. Therefore, in order to obtain a manageable number of links for modelling of work trips for the entire city and also for specific parts of the city, it was necessary to use some adequate sampling technique. Instead of using all links in the city, some of which contain zero trips, a systematic method of sampling was used.

This was done by aggregating the 5,674 origin-destination pairs containing non-zero trips according to major destinations of work trips in the city. The Central Business District was selected to comprise all zones that have a density of over 20 trips per acre of peak hour destination trips located in the center of the city (Figure 10). Zone 0454 was excluded while zone 0022 was included in order to make the district more contiguous. This resulted in 1128 origin-destination pairs in the Central Business District. The criterion used in selecting the remaining major employment centers was to aggregate zones that receive but do not generate peak hour work trips in the city according to their proximity with each other, their geographical location and according to fairly similar employment characteristics in order to reflect the observed pattern of major employment centers in the city. These zones are important only as work trip destinations. This approach resulted in 268 origin-destination pairs for the University of Alberta, 1,091 pairs for the South east industrial zones, 993 pairs for the north west industrial zones and 405 pairs for the north east industrial zones. It is recognized that although these zones may only be receiving but not

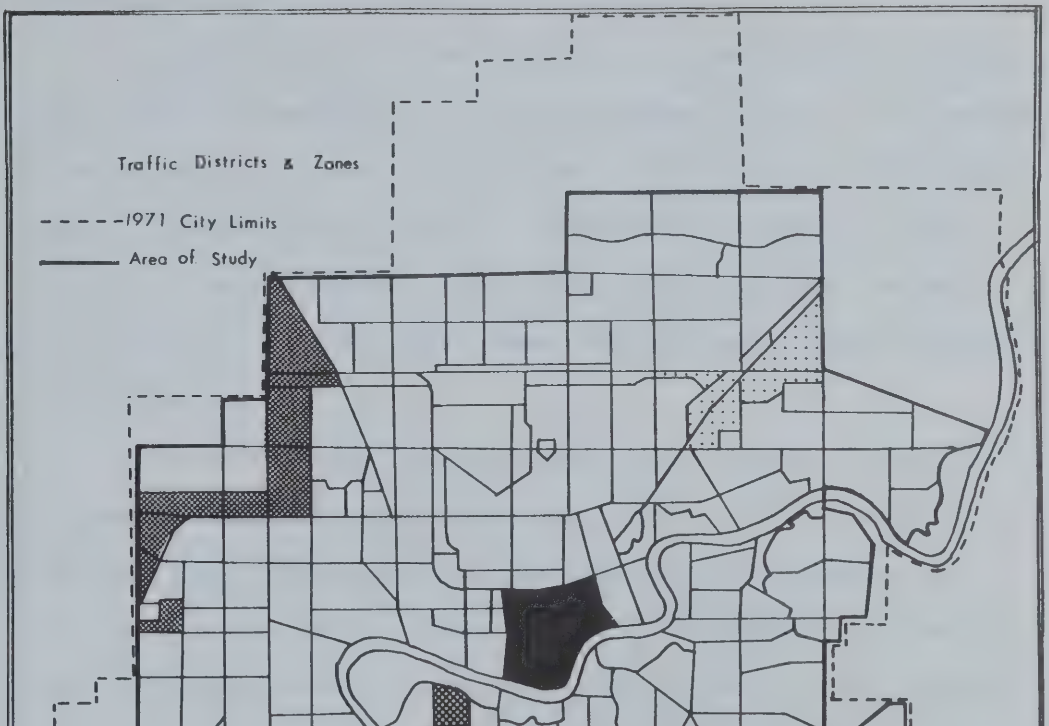

FIG. 11 MAJOR EMPLOYMENT CENTRES IN THE CITY

generating work trips, the number of work trips they recieve may not necessarily be higher than that of some zones that both generate and attract work trips.

Out of the 62,542 total A.M. peak hour work trips in the city, 31.9 percent were destined to the Central Business District, 9.6 percent to the University of Alberta, 7.4 percent to the North west industrial zones, 6.8 percent to the South east industrial zones and 2.0 percent to the North east industrial zones. These major employment centers shown in Figure 11 are the areas whose work trip patterns are examined in this study.

It is important to note, however, that a large oil refining and chemical complex situated just east of the city limits in the contiguous county of Strathcona is not included in this study. This is the Chemical Row and was eliminated by the Transportation Planning Branch of the Engineering and Transportation Department. The pattern of work trip attraction, catchment areas and work trip lengths of these major employment centers are discussed in Chapter V.

CHAPTER V

PATTERNS OF WORK TRIP ATTRACTION, WORK TRIP CATCHMENT AREAS AND WORK TRIP LENGTHS OF MAJOR EMPLOYMENT CENTERS

The number of A.M. peak hour work trips between each Traffic Zone in the area of study and each major employment center is presented in Appendix III. These values are used for obtaining the pattern of work trip attraction and identifying the work trip catchment areas of the major employment centers in the city discussed in this chapter. This chapter also discusses the pattern of work trip lengths in these centers.

5.1 PATTERNS OF WORK TRIP ATTRACTION

In order to identify the work trip attraction ability of the major centers of employment, the percentage of the entire peak hour work trips originating in each zone that was destined for each major employment center is calculated. The spatial distribution of these values within the area of study for each major employment center in the city is then presented. Figures 12 - 16 indicate the percentage of A.M. peak hour work trips originating in each traffic zone sent to each major employment center. This approach is taken in order to investigate whether a relationship exists between a traffic zone's proximity to any major employment center and the incidence of people residing in that zone working in that major employment center.

(a) Central Business District

Figure 12 shows the spatial pattern of work trip attraction to the Central Business District. Three major areas can be identified in which more than 20 percent and in some cases over 50 percent of work

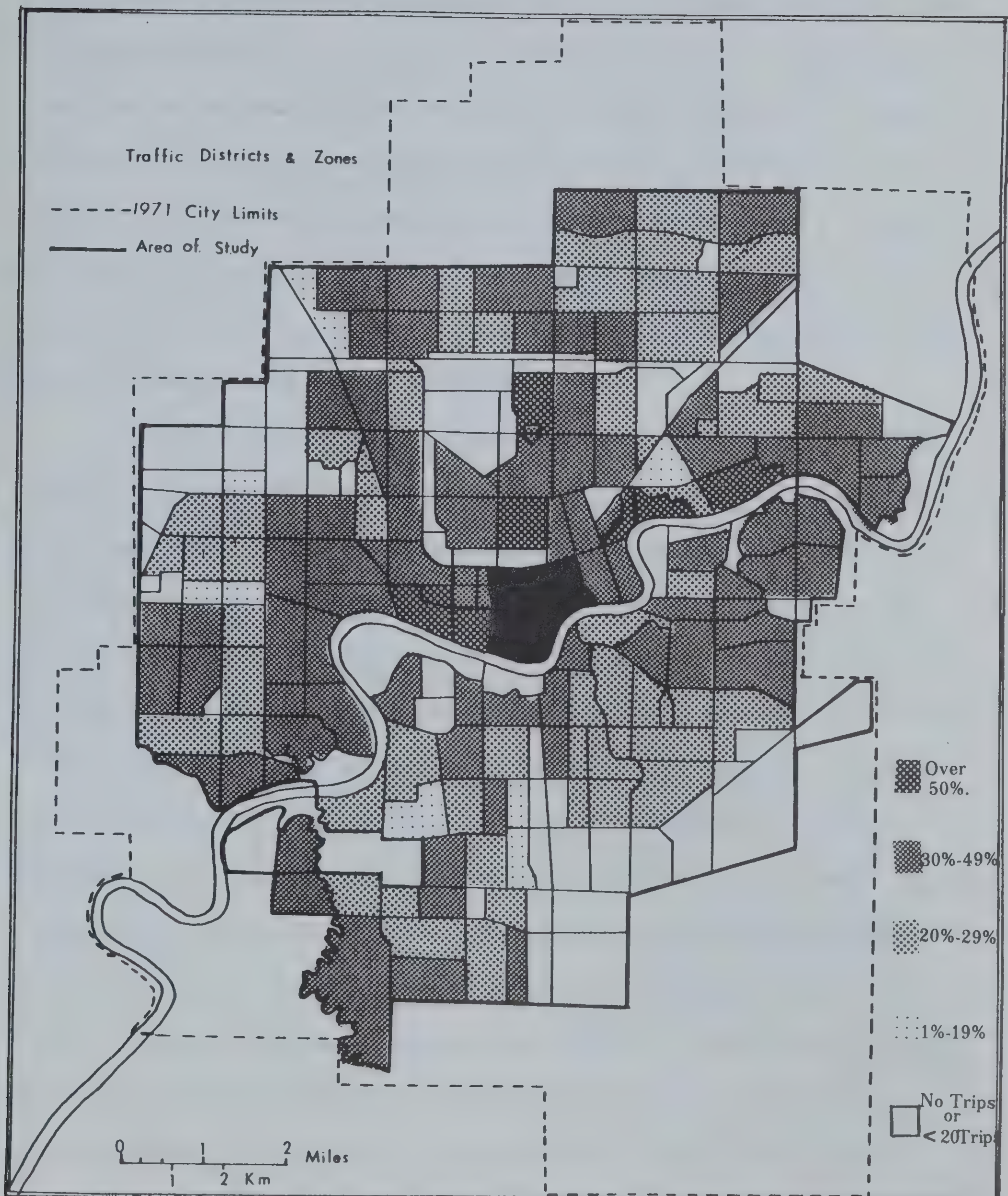

FIG. 12 WORK TRIP ATTRACTION TO THE CENTRAL BUSINESS DISTRICT

trips originating in them are destined for the Central Business District. The first major area lies directly to the west of the district where many highrise apartment buildings have been constructed in recent years, and extends westward to a high class residential area. Another major area lies to the north of the Central Business District. It extends to the east of the Industrial Airport and continues to the north of the rail yards. This area is favourably connected by the street network and bus routes to the CBD. The third major area lies to the north east and east of the district. It is made up of high density residential areas that have easy access to the district.

This observed pattern indicates that zones sending over 30 percent of their trips to the Central Business District have extended more widely over the city than was the case when Plunkett (1972) did his study. The major area to the north of the district sending over 30 percent of its work trips to the Central Business District in 1971 corresponds to an area that was sending only 20-29 percent of its work trips to the same district in 1967. A similar situation is observed for another smaller area to the east of the University of Alberta. There are a few zones in the extreme south west of the city which were sending over 30 percent of their work trips to the Central Business District in 1971. This may be explained by the improved connection between this new high class residential district in the south west and the Central Business District arising from the construction of the Quenell Bridge. On the whole, the proportion of work trips sent by most zones in the city to the Central Business District has increased tremendously in recent years.

The Central Business District attracts work trips from the entire city. This is further emphasized by the fact that, with few

exceptions, all the traffic zones in the area of study send the highest proportion of the A.M. peak hour work trips to the CBD, irrespective of their distance from the district (see Appendix III). This indicates that the residential distribution of workers in the Central Business District in Edmonton approximates that of the entire urban area. This pattern is common in most urban areas because the large and heterogeneous work force demanded by the district for its governmental, institutional, tertiary and specialized services can only be satisfied by the whole urban area. In most cases, the Central Business District is well connected by street and transit routes to all parts of the city so that there is the ability for employees in the district to live any where in the city and still get to work without enduring undue travel costs. Other factors that may also influence the residential location pattern of CBD employees include people's preferences for residential sites, neighbourhood considerations and other economic and sociological factors.

(b) The University of Alberta

Figure 13 illustrates the spatial pattern of work trip and student trip attraction to the University of Alberta. This major destination and the others discussed below receive only the second highest proportion of A.M. peak hour work trips from any zones in the city, after the highest proportion has been sent to the CBD. It attracts work trips from all over the city but its attractive ability is secondary to that of the Central Business District.

The zones which send the highest proportion of their work trips to the University are located in the south side of the city in which the University is situated. This reflects the tendency for workers and students to live near the University. It is also interesting to note

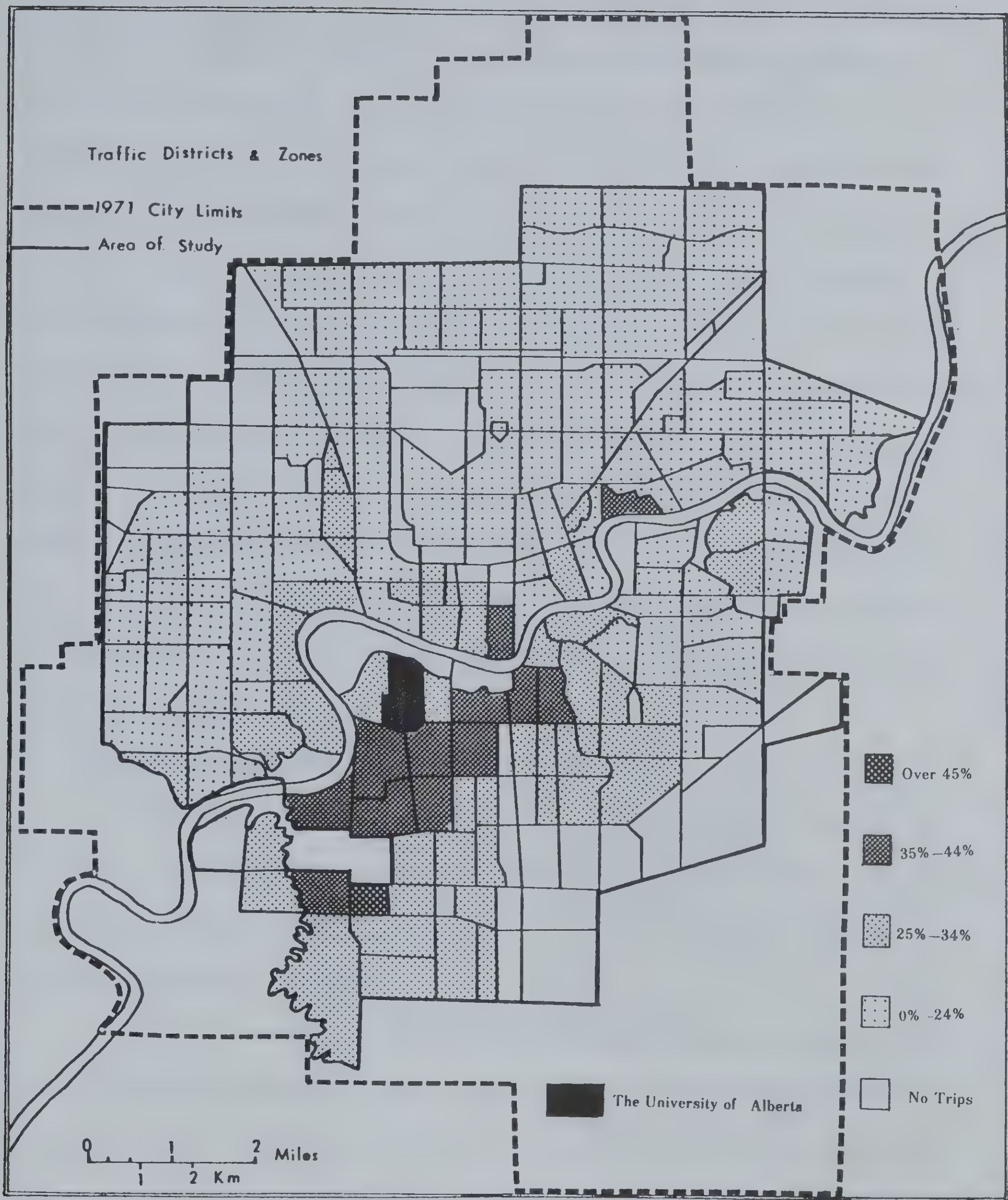

FIG. 13 WORK TRIP ATTRACTION TO THE UNIVERSITY OF ALBERTA

that the zone in which Michener Park is located sends over 80 percent of its total A.M. peak hour work trips to the University of Alberta. This is explained by the fact that Michener Park is the University residential complex for married students and that it is observed that the wives of many students living in this complex work in the University.

The University attracts a variety of workers and students whose residential location decision is influenced by family and economic considerations. These include the wives of professors and students working in the University and those students who live at home with their parents. Although, the University attracts a large number of trips, it consists of only two traffic zones. All these may have contributed to make the attempts to develop models explaining the factors that underly the trips made to the University unsuccessful. These models are not discussed in Chapter VI.

(c) Other Employment Centers

Figures 14 - 16 illustrate the spatial pattern of work trip attraction to each of the industrial areas in the city. These industrial areas have a fairly similar pattern of work trip attraction and are therefore discussed together.

An examination of the pattern of distribution of commuters to these peripheral industrial areas indicates a more tightly clustered pattern around each destination district and they all show a strong distance-decay effect. This observed pattern indicates the tendency for workers to live near their places of work.

It is interesting to note that each industrial district draws some work trips from all parts of the city. As in the case of the University of Alberta discussed earlier, the attractive ability of each

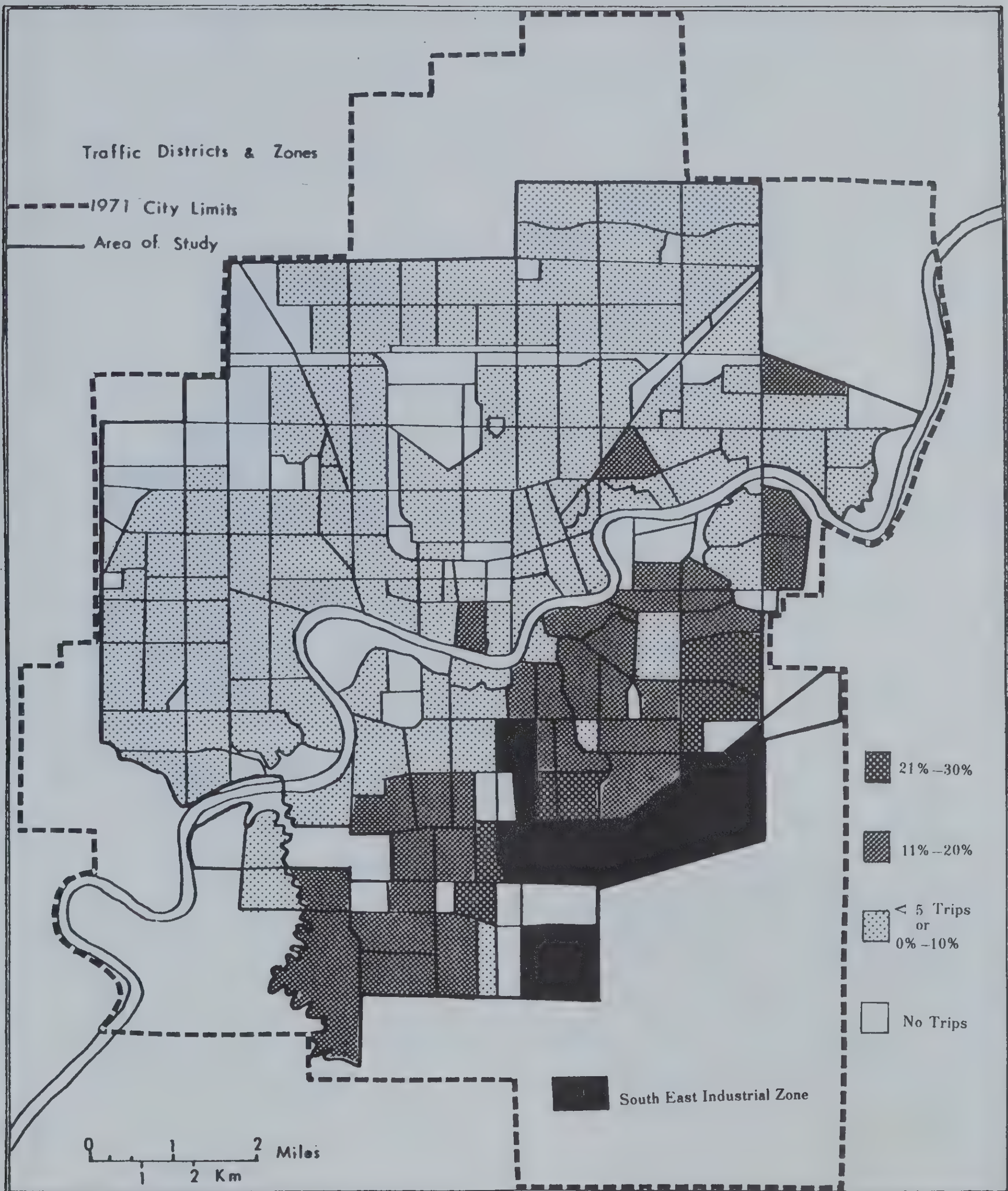

FIG. .14 WORK TRIP ATTRACTION TO THE SOUTH EAST INDUSTRIAL ZONE

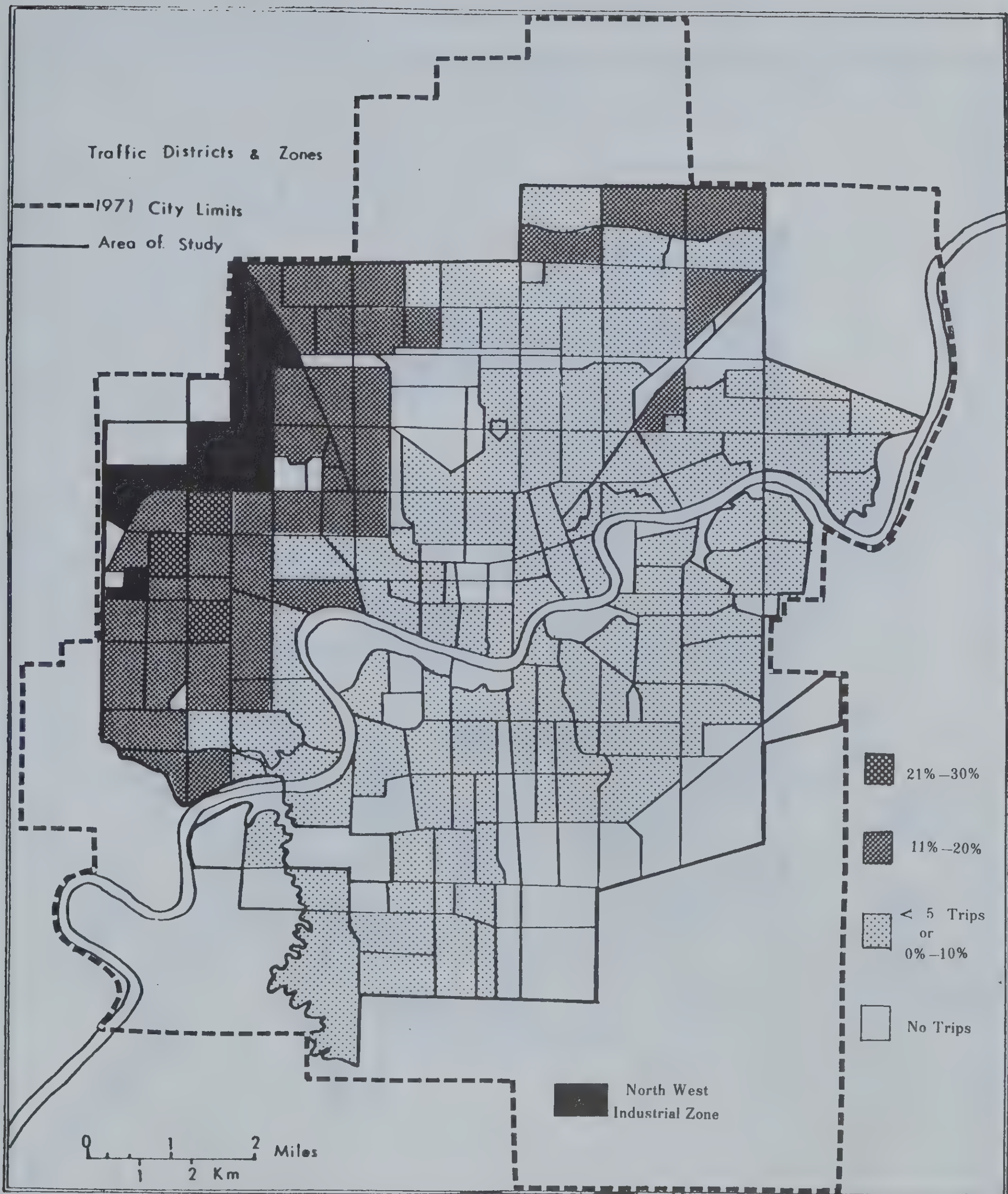

FIG 15 WORK TRIP ATTRACTION TO THE NORTH WEST INDUSTRIAL ZONE

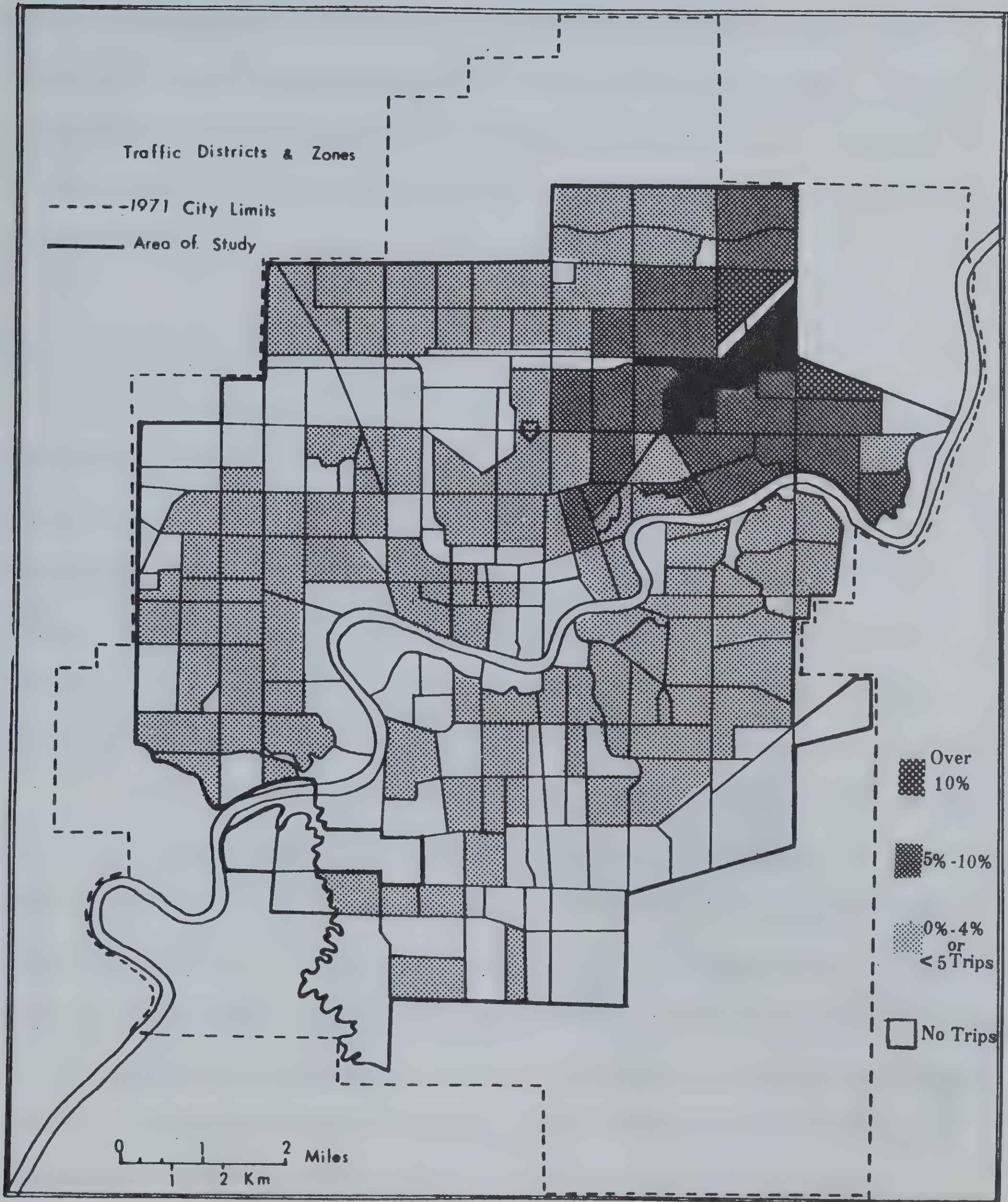

FIG.16 WORK TRIP ATTRACTION TO THE NORTH EAST INDUSTRIAL ZONES

industrial district is secondary to that of the Central Business District. The dominating effect of the work trip demand of the CBD is such that it attracts the highest percentage of workers originating in most zones. The second highest percentage is then sent to one of the other remaining major employment centers. This is an important fact to be taken into consideration with regard to the relative attractive ability for work trips by the major employment centers in the city.

5.2 WORK TRIP CATCHMENT AREAS

In order to identify the work trip catchment areas of the major employment centers in the city, the percentage of each employment center's demand for work trips satisfied by each zone in the area of study is calculated. Then, for each zone, the major employment center with the highest percentage is considered to incorporate that zone within its catchment area. This approach allows a definition of catchment areas which are not obscured by the dominance of the Central Business District.

Figure 17 presents the work trip catchment areas of the major employment center in the city including the Central Business District. Although the CBD receives the highest proportion of work trips of most zones in the city, the demand for work trips in the district is so high that the percentages obtained for the CBD is much lower than that obtained for other employment centers. This approach seems to conceal the dominating effect of the CBD but the tendency for catchment areas of other employment centers to be localized around each destination area is observed. This trend is slightly obscured by the influence of the CBD and in some cases the University of Alberta.

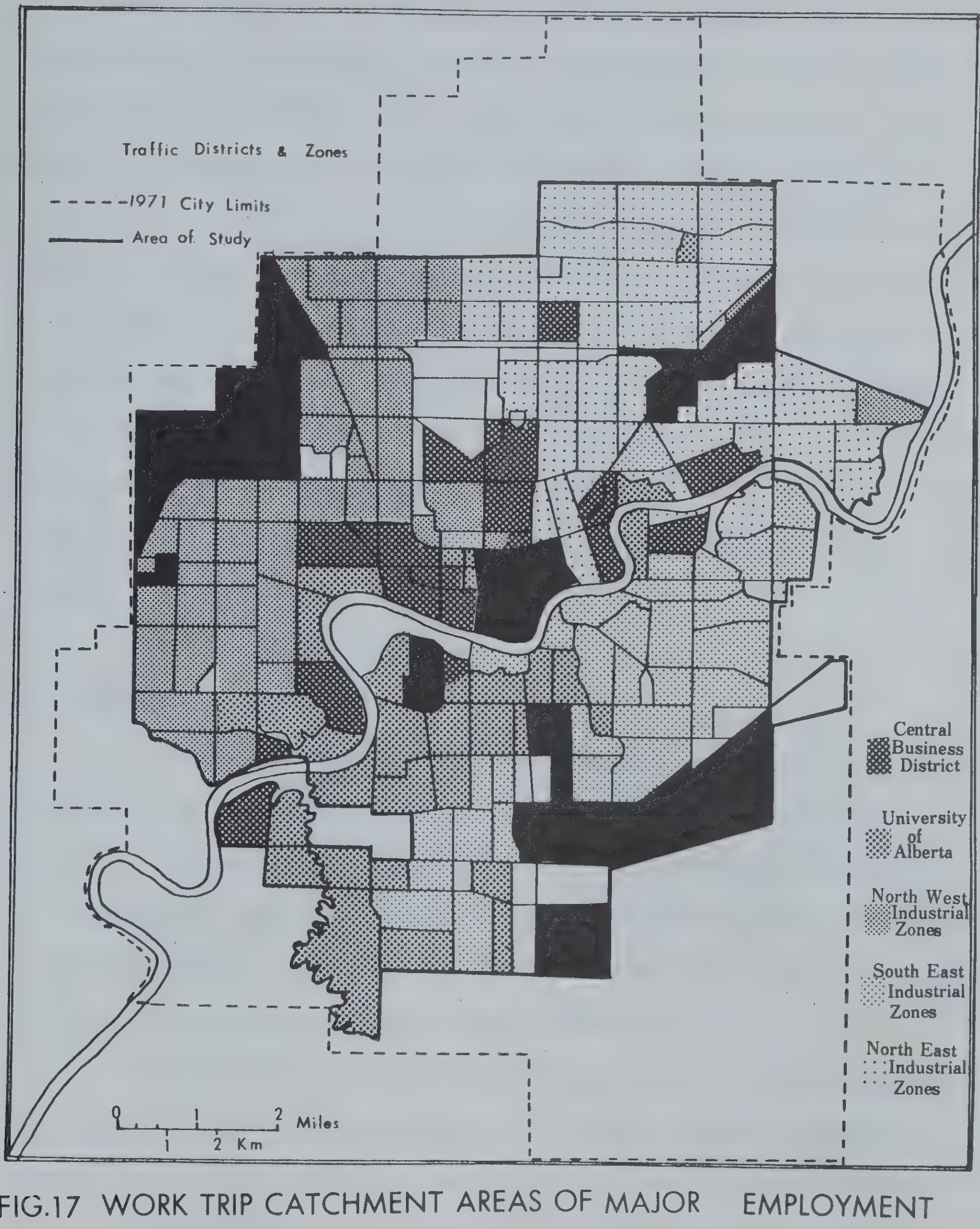

FIG.17 WORK TRIP CATCHMENT AREAS OF MAJOR EMPLOYMENT CENTERS (I)

Figure 18 presents the work trip catchment areas of other major employment centers being considered excluding the Central Business District. It shows that when CBD is excluded the work trip catchment areas become more distinct. It indicates a marked concentration of each major employment center's work trip catchment area around that major center. Most zones in the south west of the city and isolated pockets in the north of the city make up the catchment area for the University of Alberta. The general trend for the remaining major centers is such that traffic zones in the north west, south east, and north east of the city comprise the work trip catchment areas of the North west, South east and North east industrial districts, respectively. There are a few minor exceptions to this general trend and such anomolies involve only a few trips (1 or 2 trips in most cases). It is possible that they may have occured by chance.

5.3 WORK TRIP LENGTHS

In order to measure the spatial pattern of work trip attracting capacity of the employment centers, the number of workers arriving at each major destination from specific distances or the work trip lengths are aggregated. This approach is used to investigate what percentage of actual work trips demanded by each major employment center is satisfied as distance from that major destination increases.

Table 4 shows the percentage of total trips and the cumulative percentage of total work trip demand of the major employment centers derived from specific distances away from these centers. Each center receives up to 25 percent of its work trips from places less than 3 miles away. All the centers, except the North west and the South east industrial districts receive at least 80 percent of their work trips

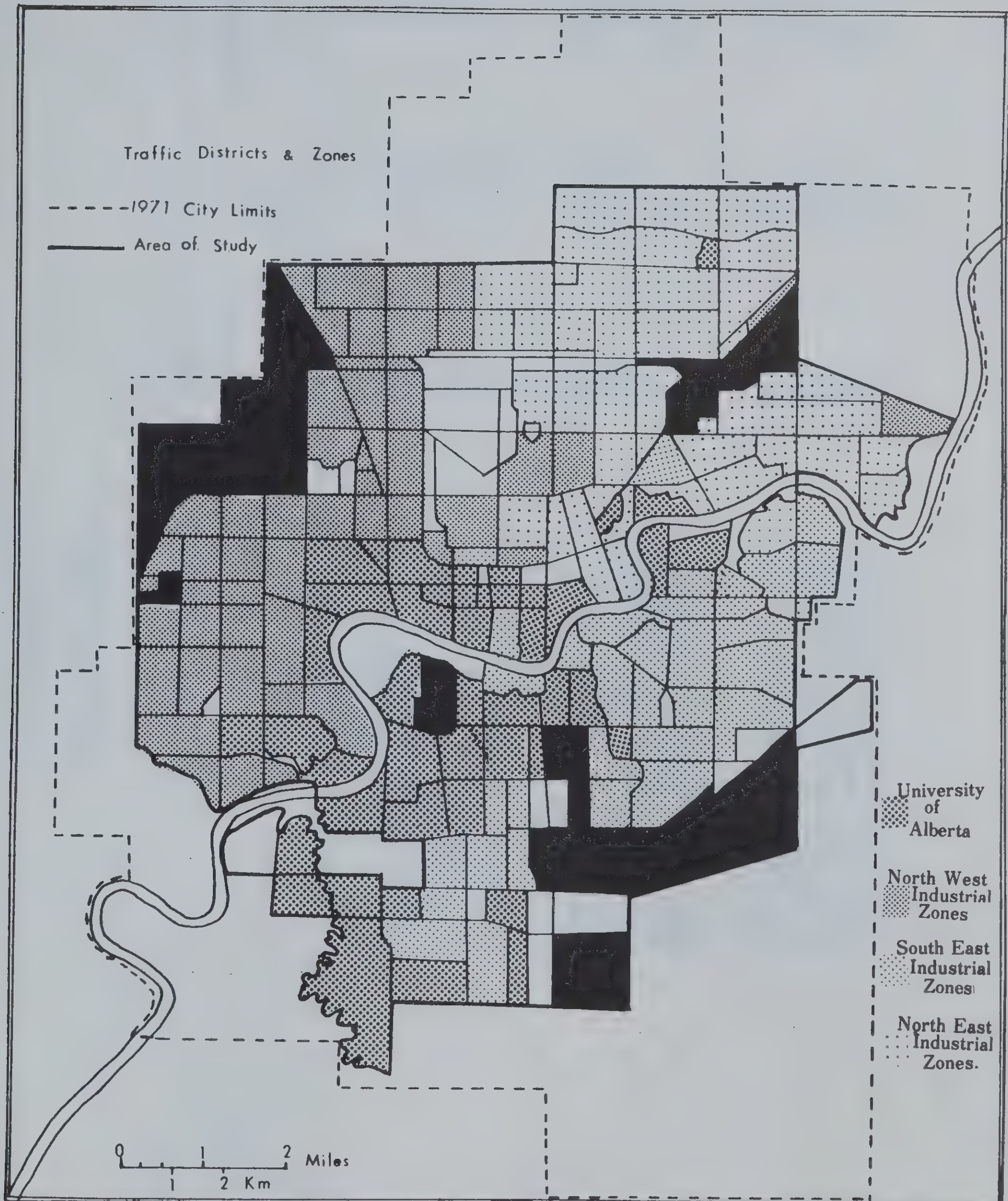

FIG. 18 WORK TRIP CATCHMENT AREAS OF MAJOR EMPLOYMENT CENTERS (II)

TABLE 4

WORK TRIP LENGTHS

Distance in Tenths of a Mile (Sixtenths of a Kilometer)	Location	Number of Work Trips	% of Total	Cumulative % of Total
0-10				
	Central Business District	305	1.5	1.5
	University of Alberta	148	2.4	2.4
	North West Industrial District	97	2.1	2.1
	South East Industrial District	83	2.0	2.0
	North East Industrial District	41	3.2	3.2
11-20				
	Central Business District	2,209	11.1	12.6
	University of Alberta	820	13.1	15.6
	North West Industrial District	532	11.5	13.6
	South East Industrial District	515	12.1	14.1
	North East Industrial District	274	21.4	24.6
21-30				
	Central Business District	3,471	17.4	30.0
	University of Alberta	760	12.2	27.7
	North West Industrial District	654	14.1	27.7
	South East Industrial District	693	16.3	30.4
	North East Industrial District	326	25.5	50.1

TABLE 4 - Continued

Distance in Tenths of a Mile (Sixtenths of a Kilometer)	Location	Number of Work Trips	% of Total	Cumulative % of Total
31-40				
	Central Business District	3,775	18.9	48.9
	University of Alberta	1,329	21.3	49.0
	North West Industrial District	688	14.8	42.5
	South East Industrial District	706	16.6	47.0
	North East Industrial District	191	14.9	65.0
41-50				
	Central Business District	3,776	18.9	67.8
	University of Alberta	1,500	24.0	73.0
	North West Industrial District	601	13.0	55.5
	South East Industrial District	495	11.7	58.7
	North East Industrial District	132	10.3	75.3
51-60				
	Central Business District	2,779	14.1	81.8
	University of Alberta	810	13.0	86.0
	North West Industrial District	416	9.0	64.5
	South East Industrial District	380	8.9	67.6
	North East Industrial District	118	9.2	84.5

TABLE 4 - Continued

Distance in Tenths of a Mile (Sixtenths of a Kilometer)	Location	Number of Work Trips	% of Total	Cumulative % of Total
61-70				
	Central Business District	1,955	9.8	91.6
	Univeristy of Alberta	342	5.5	91.5
	North West Industrial District	424	9.2	73.7
	South East Industrial District	366	8.6	76.2
	North East Industrial District	68	5.3	89.8
71-80				
	Central Business District	1,263	6.3	97.9
	University of Alberta	138	2.2	93.7
	North West Industrial District	464	10.0	83.7
	South East Industrial District	297	7.0	83.2
	North East Industrial District	32	2.5	92.3
81-90				
	Central Business District	352	1.8	99.7
	University of Alberta	220	3.5	97.2
	North West Industrial District	382	8.2	91.9
	South East Industrial District	352	8.3	91.5
	North East Industrial District	39	3.2	95.5

TABLE 4 - Continued

Distance in Tenths of a Mile (Sixteenths of a Kilometer)	Location	Number of Work Trips	% of Total	Cumulative % of Total
91-100				
	Central Business District	35	.2	99.9
	University of Alberta	79	1.3	98.5
	North West Industrial District	255	5.5	97.4
	South East Industrial District	165	3.9	95.4
	North East Industrial District	13	1.0	96.5
101-110				
	University of Alberta	75	1.2	99.7
	North West Industrial District	95	2.1	99.5
	South East Industrial District	120	2.8	98.2
	North East Industrial District	11	0.9	97.4
111-120				
	University of Alberta	30	0.5	100.2
	North West Industrial District	19	0.4	99.6
	South East Industrial District	57	1.3	99.5
	North East Industrial District	18	1.4	99.8
121-130				
	North West Industrial District	3	.06	99.6
	South West Industrial District	19	.5	100.0
	North East Industrial District	11	.9	99.7

TABLE 4 - Continued

Distance in Tenths of a Mile (Sixtenths of a Kilometer)	Location	Number of Work Trips	% of Total	Cumulative % of Total
131-140				
	North West Industrial District	-	-	-
	South East Industrial District	1	.02	100.02
	North East Industrial District	4	.3	100.0
141-150				
	North West Industrial District	2	.04	100.0
	South East Industrial District	1	.02	100.04
151-160				
	North West Industrial District	1	.02	100.02

from places not more than 6 miles away. These indicate the tendency for workers to live near their places of work. Each center receives over 90 percent of its work trips from places less than 9 miles away.

Due to its centrality, the longest work trip to the Central Business District is only 10 miles. For the same reason, the University of Alberta has the longest work trip length of 12 miles. The situation in the industrial districts is quite different. The longest work trip to the North east industrial district is 14 miles, while it is 15 miles for the South east industrial district and 16 miles for the North west industrial district. This seems anomalous but may be explained by the fact that these industrial districts are located in the periphery of the city. Only a few trips, often just 1 or 2 trips came from such long distances to these centers and it is always expected that several such minor anomalies will occur by chance.

It would appear that there is not much variation in the pattern of work trip lengths to these major employment centers. All receive work trips from all over the city and the proportion of their total work trip demand satisfied as the distance from these centers increase are fairly comparable. In spite of this apparent similarity the commuting pattern of the CBD differs in several respects from the pattern for the other major employment centers. The dominant effect of the CBD's demand for work trips is such that it attracts the highest number of work trips from most zones in the city after which these zones send their second highest trips to any of the other major destinations. This indicates that the work trip attracting abilities of the other major destinations are secondary to that of the CBD. All major employment centers in the city attract work trips from all parts of the city but the spatial

pattern of attraction for the CBD is quite different from the pattern for the other major centers. Whereas the spatial pattern and intensity of attraction for the CBD approximates the residential density pattern for the city, other major employment centers exhibit a denser pattern around each district with a strong distance-decay effect. This major difference in the spatial pattern of attraction is not reflected in the observed work trip lengths for these centers. This may be attributed to the fact that although the CBD's demand for work trips is satisfied from all directions in the city while the demand of other major centers (except the University of Alberta) is satisfied only from one direction, the increasing number of zones from which other major centers receive work trips compensates for the fewer number of work trips received from each zone. These differences between the commuting pattern to the CBD and to other major employment centers in the city deserves more investigation. The trip distribution models of Chapter VI serve to shed some light on these differences.

CHAPTER VI

MODELING PATTERNS OF WORK TRIP DISTRIBUTION IN EDMONTON

In the use of multiple linear regression in this study, the F-ratio hypothesis testing procedure is used to test the statistical significance of the regression analysis. The choice by most researchers of any conventional level of significance is inadequate and often misleading because this approach does not reflect the differences in the types of empirical problem being treated. The primary objective of the analysis is to explain the inter-relationships between work tripmaking and a number of "explanatory" variables and so the major aim is to emphasize the strengths of the relationships obtained. Under these circumstances, a low level of significance is appropriate.

First, all variables introduced in the regression are included in the equation and then the regressions are re-run without insignificant variables or variables that are significant at an α level of only .25. This enables the importance of the variables as indicated by their level of significance, to be used as a basis for systematic elimination of variables until only highly statistically significant regression coefficients are obtained. Detailed definition of the descriptive statistics associated with the multiple linear regression model are presented in Appendix IV.

6.1 FITTING THE MODELS

STEP 1: The geographical distribution of employment opportunities (D_j) is fairly concentrated in the major centers of employment in the city while the distribution of workers in each zone (O_i) is fairly dispersed, with varying densities, within the city. These two variables which are major explanatory variables in trip distribution models are

entered first.

STEP 2: The measures of spatial separation in the form of distance or travel time may affect the volume of work trip interchanges between pairs of zones. Distance and weighted travel time are introduced in separate runs in order to find out whether tripmakers view spatial separation more in terms of distance or of travel time.

STEP 3: Automobile ownership ratio is entered next. It is expected that the rate of automobile ownership ratio would be positively related to the number of work trips made by automobile.

STEP 4: Parking cost at destination may limit the number of work trips that may be made by automobile, so this variable is entered next. It is expected that the higher the parking cost, the fewer the number of work trips by automobile made to that destination. However, this situation may be complicated by the fact that employee parking stalls are often provided in some major employment centers. It is also possible that high cost of parking at destination may only divert more trips to the transit, thus resulting in increased modal split instead of lower volume of trips.

STEP 5: Accessibility to the transit system is important in trip distribution since it determines the number of work trips originating in a zone made by transit. Each of the accessibility indices, namely choice modal split (CHOICE MSPLIT) total modal split (TOTAL MSPLIT) and automobile driver captive modal split (AUTOCAPTIVE MSPLIT) are entered in separate runs. Of these, the best model indicates which is the most appropriate measure of transit accessibility for zones sending work trips to the employment center under consideration.

STEP 6: The proportion of residential land with low, medium

and high density housing in each zone is related to the number of work trips originating in a zone (O_i). Each type of residential land use proportion namely, LOW RES, MED RES or HIGH RES is entered into separate runs in order to determine which is most significantly related to work tripmaking to each major employment center.

STEP 7: After the linear forms of the models have been fitted, common logarithmic transformation (Base 10 logarithm) of the variables is used to obtain log/log models. This approach is taken in order to determine how the transformation improves the level of explanation of the models. The functional form obtained is such that the log of work trip demand is linear in the log of the explanatory or independent variables used.

The accessibility indices and the proportion of residential land with low, medium or high density housing are not transformed into logarithm because some of the observations have zero values for these variables.

STEP 8: It is recognized that there may be differences in the factors affecting work trips due to their different locations in the city. Therefore, the use of dummy variables indicating the locations to which work trips are destined are also investigated. First, two dummy variables indicating whether a work trip was made to the Central Business District or to an industrial zone are used. Then, four dummy variables indicating whether a work trip was made to the Central Business District or to any of the three industrial zones in the city are also used. The models obtained for each major employment center and combinations of these centers are presented in the following section.

6.2 CENTRAL BUSINESS DISTRICT

1. Multiple R = .814 $F(2,1043) = 1023.$ $\alpha = .0005$ $R^2 = .662$

Variables	b	F(1,1043)	α
O_i	.0473	1338.	.0005
D_j	.00658	792.	.0005

Constant -19.2

O_i and D_j are strongly associated with work tripmaking to the Central Business District. The importance of O_i reflects the fact that the spatial pattern of work trip attraction to the CBD approximates the residential distribution of workers in the city since most zones send their highest number of work trips to the district. The attractiveness of the Central Business District (D_j) is also a major factor that explains work tripmaking to the district.

2. Multiple R = .818 $F(3,1042) = 701.$ $\alpha = .0005$ $R^2 = .669$

Variables	b	F(1,1042)	α
O_i	.0475	1370.	.0005
D_j	.00661	812.	.0005
DIST	-.0758	19.8	.0005

Constant -16.1

Distance is inversely and significantly related to work trip making to the Central Business District.

3. Multiple $R = .820$ $F(3,1042) = 711.$ $\alpha = .0005$ $R^2 = .672$

Variables	b	F(1,1042)	α
O_i	.0478	1398.	.0005
D_j	.00667	833.	.0005
W TTIME	-.265	30.5	.0005

Constant -19.3

Like distance, weighted travel time is also inversely and significantly related to work trip making to the Central Business District. This seems to indicate that work tripmakers to the district view spatial separation either in terms of distance or of travel time. This relationship remains stable, even when other variables related to work trips to this district are considered (See Appendix VI (a) Runs 4 - 7). Although the sign is stable, it is interesting to note that neither distance nor travel time increases the level of explanation significantly. Possible verifications of this finding are discussed in a later section in which the CBD and industrial zone models are considered.

4. Multiple $R = .819$ $F(4,1041) = 529.$ $\alpha = .0005$ $R^2 = .670$

Variables	b	F(1,1041)	α
O_i	.0470	1305.	.0005
D_j	.00661	816.	.0005
DIST	-.0822	22.8	.0005
AUTO	11.3	5.32	.025

Constant -19.5

Automobile ownership is positively related to work tripmaking to the Central Business District and it is fairly significant. However, it does not increase the amount of variation explained by the model considerably.

5. Multiple R = .819 F(5,1040) = 423. α = .0005 R^2 = .670

Variables	b	F(1,1040)	α
O_i	.0470	1303.	.0005
D_j	.00658	683.	.0005
DIST	-.0822	22.8	.0005
AUTO	11.3	5.27	.025
PCOST	.00036	.105	NOT SIG.

Constant -19.5

Parking cost at destination is not a strong deterrent to work tripmaking to this district and is therefore removed in subsequent runs. This may partly be explained by the fact that employee parking stalls are often provided free or subsidized heavily by some employers in this district. Moreover, since the district is well served by the transit system, the high cost of parking diverts many work trips to the transit resulting in increased modal split.

6. Multiple $R = .819$ $F(5,1040) = 424.$ $\alpha = .0005$ $R^2 = .671$

Variables	b	F(1,1040)	α
O_i	.0469	1303.	.0005
D_j	.00663	820.	.0005
DIST	-.0831	23.3	.0005
AUTO	11.8	5.70	.025
CHOICE MSPLIT	-1.75	3.24	.10

Constant -19.1

Choice modal split is the measure of transit service or accessibility which is slightly significantly related to work trips to the Central Business District. Total modal split is not significant while the proportion of workers who are captive to the automobile is only slightly significant ($\alpha = .25$) in the explanation of work trips to the district. These are shown in Appendix VI (a), runs 1 and 2 respectively. However, choice modal split does not increase the amount of variation explained by the modal.

7. Multiple $R = .821$ $F(6,1039) = 359.$ $\alpha = .0005$ $R^2 = .674$

Variables	b	F(1,1039)	α
O_i	.0466	1293.	.0005
D_j	.00663	826.	.0005
DIST	-.0590	9.91	.005
AUTO	15.1	9.17	.005

CHOICE MSPLIT	-1.43	2.19	.25
LOW RES	-5.2	9.92	.005

Constant -16.7

The proportion of residential land with low density residential housing is inversely related to the work trips sent by each zone to this district.

8. Multiple R = .821 $F(6,1039) = 358.$ $\alpha = .0005$ $R^2 = .674$

Variables	b	F(1,1039)	α
O_i	.0467	1293.	.0005
D_j	.00663	827.	.0005
DIST	-.0617	11.2	.001
AUTO	15.8	9.82	.005
CHOICE MSPLIT	-1.45	2.23	.25
MED RES	5.6	9.65	.005

Constant -22.4

The proportion of residential land with medium density residential housing is positively related to work trips sent by each residential zone to this district. It is interesting to note that this variable and the proportion of residential land with low density housing are related to work trips to this destination in opposite directions.

However, neither of the proportion of residential land use

with low density or medium density housing improves the level of explanation in the models. Also, their inclusion results in the choice modal split being reduced from a former higher level of significance ($\alpha = .10$) to a much lower level of significance ($\alpha = .25$).

Table 5 presents the results of the regressions obtained from the logarithmic transformation of the variables. The functional form obtained from this transformation results in the general multiple linear regression equation,

$$T_{ij} = b_o + b_1 O_i + b_2 D_j - b_3 \text{ DIST}$$

being changed to

$$\text{Log } T_{ij} = b_o + b_1 \log O_i + b_2 \log D_j - b_3 \text{ Log DIST}$$

or

$$T_{ij} = b_o \frac{O_i^{b_1} D_j^{b_2}}{\text{DIST}^{b_3}}$$

This logarithmic transformation indicates a closer relationship with the traditional gravity model. Therefore, the amount of variation explained by each model is significantly improved in these models in most cases.

All the models perform much better than their equivalents. Again, O_i and D_j are predominant in explaining the distribution of CBD work trips, while distance, weighted travel time and automobile ownerhip are still as significant in this form as in the linear form. Parking cost remains insignificant. It is however rather surprising that the level of significance of the measures of spatial separation, namely, distance and weighted travel time, decrease in significance in the logarithmic forms.

TABLE 5

BUSINESS DISTRICT (LOG TRANSFORMATIONS)

1. Multiple R = .850 $F(2,1042) = 1360.$ $\alpha = .0005$ $R^2 = .723$

Variables	b	F(1,1042)	α
Log of O_i	.785	2028.	.0005
Log of D_j	.969	838.	.0005

Constant -4.16

2. Multiple R = .852 $F(3,1041) = 917.$ $\alpha = .0005$ $R^2 = .726$

Variables	b	F(1,1041)	α
Log of O_i	.792	2046.	.0005
Log of D_j	.972	849.	.0005
Log of DIST	-.0947	9.37	.005

Constant -4.04

3. Multiple R = .851 $F(3,1041) = 914.$ $\alpha = .0005$ $R^2 = .725$

Variables	b	F(1,1041)	α
Log of O_i	.794	1995.	.0005
Log of D_j	.975	849.	.0005
Log of W TTIME	-.104	6.65	.01

Constant -4.07

TABLE 5 - Continued

4. Multiple $R = .853$ $F(4,1040) = 693.$ $\alpha = .0005$ $R^2 = .727$

Variables	b	F(1,1040)	α
Log of O_i	.780	1875.	.0005
Log of D_j	.971	852.	.0005
Log of DIST	-.119	13.6	.0005
Log of AUTO	.204	6.37	.025

Constant -3.87

5. Multiple $R = .823$ $F(5,1039) = 554.$ $\alpha = .0005$ $R^2 = .727$

Variables	b	F(1,1039)	α
Log of O_i	.780	1874.	.0005
Log of D_j	.972	835.	.0005
Log of DIST	-.119	13.6	.0005
Log of AUTO	.204	6.38	.025
Log of PCOST	-.00250	.013	NOT SIG.

Constant -3.86

Many interesting conclusions can be drawn from these results of the analysis of work trips to the CBD. Because the work trip catchment area of the CBD is fairly coincident with the residential distribution of workers in the city, O_i is highly correlated with work trips or T_{ij} (r = .637) and is therefore the major explanatory variable. This indicates that work trip attraction to the CBD is well explained by the intensity of work trip generation of the zones. The importance of the district as a major employment center also explains it high attractive ability for work trips. After these two major variables, several others seem to be significantly related to work tripmaking to the district but they do not increase the amount of variation explained by O_i and D_j. The logarithmic transformation of the variables improves the level of explanation of the models and as with the linear forms, generation explains the highest proportion of variation.

6.3 SOUTH EAST INDUSTRIAL ZONES

1. Multiple R = .474 F(2,856) = 124. α = .0005 R^2 = .225

Variables	b	F(1,856)	α
O_i	.00728	178.	.0005
D_j	.00580	85.0	.0005

Constant -1.91

As expected, O_i and D_j are important explanatory variables related to the work trips to the south east industrial zones.

2. Multiple R = .637 F(3,855) = 195. α = .0005 R^2 = .225

Variables	b	F(1,855)	α
O_i	.00707	218.	.0005
D_j	.00645	137.	.0005
DIST	-.0663	262.	.0005

Constant 1.72

Distance is inversely and significantly related to work tripmaking to these industrial zones. In fact, it emerges as the most important explanatory variable since its introduction almost doubles the amount of variation explained by O_i and D_j combined.

3. Multiple R = .633 F(3,855) = 191. α = .0005 R^2 = .401

Variables	b	F(1,855)	α
O_i	.00725	227.	.0005
D_j	.00655	140.	.0005
W TTIME	-.252	252.	.0005

Constant 1.90

Weighted travel time is also inversely and significantly related to work tripmaking to the south east industrial zones. However, it is not as important a contributor to variance explained as distance.

4. Multiple R = .641 F(4,854) = 149. α = .0005 R^2 = .410

Variables	b	F(1,854)	α
O_i	.00684	197.	.0005
D_j	.00646	138.	.0005
DIST	-.0660	258.	.0005
AUTO	4.75	5.64	.025

Constant .168

Automobile ownership ratio of the origin zone is positively and fairly significantly related to work trips in these zones. However, it contributes only marginally to increasing the level of explanation of the model.

5. Multiple R = .641 F(5,853) = 119. α = .0005 R^2 = .410

Variables	b	F(1,854)	α
O_i	.00684	197.	.0005
D_j	.00659	114.	.0005
DIST	-.0658	257.	.0005
AUTO	4.76	5.66	.025
PCOST	-.00158	.197	NOT SIG.

Constant .322

Parking cost at destination is not a strong deterrent to work tripmaking in these zones. It is therefore excluded from subsequent runs.

6. Multiple R = .657 $F(5,853) = 130.$ $\alpha = .0005$ $R^2 = .432$

Variables	b	F(1,853)	α
O_i	.00735	228.	.0005
D_j	.00606	124.	.0005
DIST	-.0611	221.	.0005
AUTO	5.68	8.28	.005
AUTOCAP MSPLIT	24.3	32.0	.0005

Constant -.725

The proportion of automobile captives in a zone is highly significantly related to work trips ending in these zones. Choice modal split and total modal split are only slightly significantly related to the same trips with α levels of .01 and .05 respectively (Appendix VI (b) runs 1 and 2).

7. Multiple R = .672 $F(6,852) = 117.$ $\alpha = .0005$ $R^2 = .451$

Variables	b	F(1,852)	α
O_i	.00754	246.	.0005
D_j	.00614	131.	.0005
DIST	-.0642	247.	.0005
AUTO	2.61	1.67	.25

AUTOCAP MSPLIT	23.2	30.0	.0005
LOW RES	2.99	30.2	.0005

Constant -2.20

The proportion of residential land with low, medium and high density housing are all significant in explaining work trips to the south east industrial zones but the proportion of residential land with medium density and high density housing explain less amount of variation (Appendix VI (b) runs 3 and 4) than the proportion of low residential land with low density housing presented above. However, since its inclusion reduces the significance level of the automobile ownership ratio (from $\alpha = .005$ in run 6 to $\alpha = .25$ in run 7) the car ownership ratio is removed in the next run to obtain the following model which is the best linear model for this destination.

8. Multiple R = .671 F(5,853) = 140. $\alpha = .0005$ $R^2 = .450$

Variables	b	F(1,853)	α
O_i	.00766	264.	.0005
D_j	.00615	132.	.0005
DIST	-.0648	255.	.0005
AUTOCAP MSPLIT	22.7	28.9	.0005
LOW RES	3.19	37.1	.0005

Constant -1.50

Table 6 shows the results of the regressions obtained from the logarithmic transformations of the variables. The amount of variation explained in each model is very slightly improved when compared with their equivalents in the linear models. The significance of the automobile ownership ratio is reduced (from α = .025 to α = .10) in the logarithmic model. Parking cost at destination remains insignificant in the logarithmic form.

In the south east industrial zones, the model obtained from O_i, D_j and DIST is the most meaningful model since these are the major explanatory variables related to work tripmaking to these zones. The proportion of automobile captives and the proportion of low density residential land further improve the model slightly. Parking cost is not significant and the automobile ownership ratio is rather unstable in the slight contribution it makes in increasing the amount of variation explained. Logarithmic transformation of the variables increase the level of explanation of the models.

TABLE 6

SOUTH EAST INDUSTRIAL ZONES (LOG TRANSFORMATIONS)

1. Multiple $R = .480$ $F(2,856) = 128.$ $\alpha = .0005$ $R^2 = .230$

Variables	b	F(1,856)	α
Log of O_i	.489	188.	.0005
Log of D_j	.564	86.0	.0005

Constant -2.29

2. Multiple $R = .660$ $F(3,855) = 230.$ $\alpha = .0005$ $R^2 = .435$

Variables	b	F(1,855)	α
Log of O_i	.505	273.	.0005
Log of D_j	.628	145.	.0005
Log of DIST	-.678	311.	.0005

Constant -1.35

3. Multiple $R = .648$ $F(3,855) = 206.$ $\alpha = .0005$ $R^2 = .419$

Variables	b	F(1,855)	α
Log of O_i	.513	275.	.0005
Log of D_j	.642	147.	.0005
Log of W TTIME	-.783	279.	.0005

Constant -1.64

TABLE 6 - Continued

4. Multiple $R = .662$ $F(4,854) = 166.$ $\alpha = .0005$ $R^2 = .438$

Variables	b	F(1,854)	α
Log of O_i	.484	227.	.0005
Log of D_j	.628	145.	.0005
Log of DIST	-.674	307.	.0005
Log of AUTO	.235	3.80	.10

Constant -1.19

5. Multiple $R = .662$ $F(5,853) = 133.$ $\alpha = .0005$ $R^2 = .438$

Variables	b	F(1,853)	α
Log of O_i	.485	227.	.0005
Log of D_j	.656	114.	.0005
Log of DIST	-.675	308.	.0005
Log of AUTO	.236	3.85	.05
Log of PCOST	-.0837	.719	NOT SIG.

Constant -1.08

6.4 NORTH WEST INDUSTRIAL ZONES

1. Multiple R = .594 $F(2,910) = 248.$ $\alpha = .0005$ $R^2 = .353$

Variables	b	F(1,910)	α
O_i	.00750	152.	.0005
D_j	.00613	385.	.0005

Constant -2.29

O_i and D_j are important explanatory variables related to work tripmaking to these zones. D_j seems to be more important than O_i.

2. Multiple R = .689 $F(3,909) = 275.$ $\alpha = .0005$ $R^2 = .475$

Variables	b	F(1,909)	α
O_i	.00881	251.	.0005
D_j	.00603	459.	.0005
DIST	-.0676	213.	.0005

Constant 1.22

Distance is inversely and significantly related to work trips in these zones. It increases the amount of variation explained by the model considerably.

3. Multiple R = .676 $F(3,909) = 166.$ $\alpha = .0005$ $R^2 = .457$

Variables	b	F(1,909)	α
O_i	.00753	153.	.0005
D_j	.00617	388.	.0005
W TTIME	-.211	180.	.0005

Constant -2.27

Although weighted travel time is also inversely and significantly related to work trips ending in these zones, distance used as a measure of spatial separation gives a better model.

4. Multiple R = .693 $F(4,908) = 210.$ $\alpha = .0005$ $R^2 = .481$

Variables	b	F(1,908)	α
O_i	.00905	262.	.0005
D_j	.00603	463.	.0005
DIST	-.0686	220.	.0005
AUTO	-6.91	9.28	.005

Constant 3.52

Automobile ownership ratio at origin zone is fairly significantly related to work trips ending in there zones. However, as in the North east industrial zones, it has an unexpected negative sign. It is possible that this unexpected inverse relationship may be capturing a "peripheral location" factor.

5. Multiple R = .695 $F(5,907) = 169.$ $\alpha = .0005$ $R^2 = .483$

Variable	b	F(1,907)	α
O_i	.00908	265.	.0005
D_j	.00635	372.	.0005
DIST	-.0695	234.	.0005
AUTO	-7.12	9.85	.005
PCOST	-.0121	3.41	.10

Constant 4.12

Parking cost at destination is only slightly significantly related to work trips in the North west industrial zones. However, it does not increase the level of explanation by the model considerably.

6. Multiple R = .721 $F(6,906) = 163.$ $\alpha = .0005$ $R^2 = .519$

Variable	b	F(1,906)	α
O_i	.0102	338.	.0005
D_j	.00606	360.	.0005
DIST	-.0666	219.	.0005
AUTO	-6.62	9.14	.005
PCOST	-.0125	3.92	.05
AUTOCAP MSPLIT	22.2	68.9	.0005

Constant 3.13

The number of automobile captives in a zone is the best measure of transit accessibility for work trips ending in the North west industrial zones. Choice modal split is not significant while total modal split is only slightly significant.

7. Multiple R = .727 $F(7,905) = 145.$ $\alpha = .0005$ $R^2 = .528$

Variables	b	F(1,905)	α
O_i	.0104	355.	.0005
D_j	.00613	374.	.0005
DIST	-.0694	238.	.0005
AUTO	-8.72	15.3	.0005
PCOST	-.0137	4.74	.05
AUTOCAP MSPLIT	21.7	67.1	.0005
LOW RES	-2.62	17.8	.0005

Constant 1.68

8. Multiple R = .727 $F(7,905) = 145.$ $\alpha = .0005$ $R^2 = .528$

Variables	b	F(1,905)	α
O_i	.0104	355.	.0005
D_j	.00612	373.	.0005
DIST	-.0694	273.	.0005
AUTO	-9.02	16.1	.0005
PCOST	-.0136	4.68	.05
AUTOCAP MSPLIT	21.8	67.5	.0005
MED RES	-2.83	16.9	.0005

Constant [illegible]

The proportion of residential land with low and medium density housing are equally highly significant in explaining work trips ending in these zones. The proportion of residential land with high density housing is significant only at the α level of .025 (Appendix VI (c) Run 3).

Table 7 shows that all the models obtained from the logarithmic transformations of the variables are worse than their equivalents in the linear models. This contrasts sharply with the results obtained from models in the Central Business District and South east industrial zones already discussed. There is no easily recognizable explanation for this rather anomalous situation.

The general trend in the North west industrial zones is that the model obtained from O_i, D_j and DIST is the most meaningful model since these are the major explanatory variables. After these major variables, several other variables improve the model only slightly. The logarithmic transformation of the variables does not improve the level of explanation of the models.

6.5 NORTH EAST INDUSTRIAL ZONES

1. Multiple R = .373 $F(2,267) = 21.6$ $\alpha = .0005$ $R^2 = .139$

Variables	b	F(1,267)	α
O_i	.00504	35.9	.0005
D_j	.00461	7.06	.01

Constant -.426

In the north east industrial zones, O_i is more significantly related to work tripmaking to these zones than D_j. This may be reflect-

TABLE 7

NORTH WEST INDUSTRIAL ZONES (LOG TRANSFORMATIONS)

1. Multiple $R = .578$ $F(2,910) = 228.$ $\alpha = .0005$ $R^2 = .334$

Variables	b	F(1,910)	α
Log of O_i	.374	144.	.0005
Log of D_j	.698	354.	.0005

Constant -2.34

2. Multiple $R = .684$ $F(3,909) = 266.$ $\alpha = .0005$ $R^2 = .468$

Variables	b	F(1,909)	α
Log of O_i	.442	246.	.0005
Log of D_j	.707	255.	.0005
Log of DIST	-.595	229.	.0005

Constant -1.52

3. Multiple $R = .669$ $F(3,909) = 246.$ $\alpha = .0005$ $R^2 = .448$

Variables	b	F(1,909)	α
Log of O_i	.442	236.	.0005
Log of D_j	.778	515.	.0005
Log of W TTIME	-.694	188.	.0005

Constant -1.90

TABLE 7 - Continued

4. Multiple $R = .690$ $F(4,908) = 206.$ $\alpha = .0005$ $R^2 = .476$

Variables	b	F(1,908)	α
Log of O_i	.470	264.	.0005
Log of D_j	.708	462.	.0005
Log of DIST	-.609	241.	.0005
Log of AUTO	-.463	14.6	.0005

Constant -1.79

5. Multiple $R = .691$ $F(5,907) = 166.$ $\alpha = .0005$ $R^2 = .477$

Variables	b	F(1,907)	α
Log of O_i	.471	265.	.0005
Log of D_j	.727	413.	.0005
Log of DIST	-.613	243.	.0005
Log of AUTO	-.471	15.1	.0005
Log of PCOST	-.0615	1.76	.25

Constant -1.73

ing the fact that there are few employment opportunities in these zones.

2. Multiple R = .569 F(3,266) = 42.5 α = .0005 R^2 = .324

Variables	b	F(1,266)	α
O_i	.00552	54.4	.0005
D_j	.00539	12.2	.0005
DIST	-.0547	72.7	.0005

Constant 1.86

Distance is inversely and highly significantly related to work trips made to these zones. It explains as much variation as O_i and D_j combined. Also, when distance is included in the model, D_j increases in its level of significance.

3. Multiple R = .532 F(3,266) = 35.0 α = .0005 R^2 = .283

Variables	b	F(1,266)	α
O_i	.00558	52.3	.0005
D_j	.00614	14.7	.0005
W TTIME	-.200	53.3	.0005

Constant 1.87

Although weighted travel time is also inversely and significantly related to work trips ending in these zones, the use of distance as a measure of spatial separation gives a better model.

4. Multiple $R = .577$ $F(4,265) = 33.0$ $\alpha = .0005$ $R^2 = .332$

Variables	b	F(1,265)	α
O_i	.00572	57.7	.0005
D_j	.00568	13.5	.0005
DIST	-.050	52.3	.0005
AUTO	-6.53	3.36	.05

Constant 3.60

Automobile ownership ratio at origin is slightly significantly related to work trips to this destination. However, it has an unexpected relationship with tripmaking. As suggested with regard to other industrial zones, its inverse relationship with tripmaking may be capturing a "peripheral location" factor.

5. Multiple $R = .577$ $F(5,264) = 26.3$ $\alpha = .0005$ $R^2 = .333$

Variables	b	F(1,264)	α
O_i	.00573	57.6	.0005
D_j	.00629	4.79	.0005
DIST	-.0499	52.1	.0005
AUTO	-6.46	3.26	.10
PCOST	-.00231	.064	NOT SIG

Constant 3.59

Parking cost at destination is not significantly related to work tripmaking to these zones. It is therefore excluded from subsequent runs.

6. Multiple R = .632 $F(5,264) = 35.1$ $\alpha = .0005$ $R^2 = .399$

Variables	b	F(1,264)	α
O_i	.00490	44.8	.0005
D_j	.00494	11.2	.005
DIST	-.0464	49.5	.0005
AUTO	-5.61	2.7	.10
CHOICE MSPLIT	6.25	29.4	.0005

Constant 3.58

The proportion of automobile captives in a zone is the measure of accessibility that is not highly significantly related to work tripmaking to these zones (Appendix VI (d), Run 2). Although total modal split and choice modal split are equally significantly related to tripmaking, total modal split contributes in explaining less variation (Appendix V (d), Run 1). Choice modal split is therefore the measure of accessibility that is most significantly related to work tripmaking to these zones.

7. Multiple R = .645 $F(6,263) = 31.2$ $\alpha = .0005$ $R^2 = .416$

Variables	b	F(1,263)	α
O_i	.00524	50.9	.0005
D_j	.00516	12.5	.0005
DIST	-.0460	49.9	.0005
AUTO	-6.75	3.99	.05
CHOICE MSPLIT	6.03	27.9	.0005
LOW RES	2.63	7.31	.01

Constant 1.41

The proportion of residential land with low density housing and medium density housing are fairly significantly related to work trips ending in the north east industrial zones, but the model presented above is the better model while the proportion of residential land with high density housing is only slightly significant with α level of .25 (Appendix VI (d), Runs 3 and 4).

Table 8 indicates that the models obtained from the logarithmic transformations of the variables are slightly stronger than the linear models. In the logarithmic form the significance level of D_j is increased while that of automobile ownership is reduced. Parking cost remains insignificant.

As in the other industrial zones, the model obtained from O_i, D_j and DIST is the most meaningful since these are the major explanatory variables related to work tripmaking to the North east industrial zones. After these, automobile ownerhip ratio at origin zone, choice modal split

TABLE 8

NORTH EAST INDUSTRIAL ZONES (LOG TRANSFORMATIONS)

1. Multiple R = .412 $F(2,267) = 27.3$ $\alpha = .0005$ $R^2 = .170$

Variables	b	F(1,267)	α
Log of O_i	.298	40.7	.0005
Log of D_j	.367	14.6	.0005

Constant -1.30

2. Multiple R = .635 $F(3,266) = 59.8$ $\alpha = .0005$ $R^2 = .403$

Variables	b	F(1,266)	α
Log of O_i	.378	87.0	.0005
Log of D_j	.434	28.1	.0005
Log of DIST	-.643	103.7	.0005

Constant -.623

3. Multiple R = .575 $F(3,266) = 43.8$ $\alpha = .0005$ $R^2 = .331$

Variables	b	F(1,266)	α
Log of O_i	.371	74.5	.0005
Log of D_j	.478	29.8	.0005
Log of W TTIME	-.722	64.0	.0005

Constant -.942

TABLE 8 - Continued

4. Multiple $R = .635$ $F(4,265) = 44.7$ $\alpha = .0005$ $R^2 = .403$

Variables	b	F(1,265)	α
Log of O_i	.377	85.9	.0005
Log of D_j	.433	27.7	.0005
Log of DIST	-.644	88.8	.0005
Log of AUTO	.00883	.001	NOT SIG.

Constant -.616

5. Multiple $R = .635$ $F(5,264) = 35.6$ $\alpha = .0005$ $R^2 = .403$

Variables	b	F(1,264)	α
Log of O_i	.377	85.4	.0005
Log of D_j	.415	2.48	.25
Log of DIST	-.644	88.4	.0005
Log of AUTO	.00782	.001	NOT SIG.
Log of PCOST	.0157	.006	NOT SIG.

Constant -.600

and the proportion of residential land with low density housing each improves the model slightly. Logarithmic transformation of the variables increases the amount of variation explained by the models.

6.6 COMPARISON OF MODELS OBTAINED FOR THE CENTRAL BUSINESS DISTRICT WITH MODELS OBTAINED FOR THE INDUSTRIAL ZONES

A general survey of the models presented seems to indicate that although the CBD and each of the industrial zones receive work trips from all over the city, the effect of any of the measures of spatial separation, namely, distance or weighted travel time, is more significantly related to work trips made to the industrial zones. Whereas distance or weighted travel time only slightly improve the level of explanation of work trips to the CBD, these variables contribute highly and significantly to the explanation of work trips to the industrial zones. It is necessary to explore possible causes of this apparently anomalous situation.

In the fitting of the models, it has been noted that either distance or travel time along with O_i and D_j results in a model that best reflects the spatial pattern of work trip attraction to any of the industrial zones. This relationship remains stable in all the industrial zones and the inclusion of other variables in the model only improve them slightly. In the CBD where O_i and D_j are the major explanatory variables, it would appear that O_i captures the effect of distance which is probably forced to contribute mainly as an important modifier for peripheral zones. It has already been noted that although all major destinations in the city receive work trips from all parts of the city, the work trip attracting ability of the other major employment centers is secondary to that of the CBD which attracts the highest number of workers from most zones in the

city. It is this major difference between their pattern and intensity of work trip attraction that is responsible for the manner in which the measures of spatial separation relate to work tripmaking to these centers in the models.

It is also interesting to note that the proportion of low density residential land is significantly related to work trips to the industrial zones due to their surburban location while the proportion of medium density residential land is important in the CBD. It is therefore suggested that the relative importance of the different modes of transportation, differences in income, sex and age composition of the labour force for the CBD and for the industrial zones be investigated in order to find out if they also differ significantly with respect to these characteristics.

Closer examination of the models obtained for each of the industrial zones indicates a general similarity in the major factors underlying journey to work patterns to the industrial zones in the city. All work trips made to industrial zones are therefore modelled together.

6.7 ALL INDUSTRIAL ZONES

Table 9 presents the results of the regressions obtained when the three industrial zones are considered together. O_i and D_j are important explanatory variables but the inclusion of distance or weighted travel time still improve the model considerably. Although both measures of spatial separation are significant in separate industrial zones when all are considered together, distance always gives a stronger model. This indicates that workers in these industrial zones view spatial separation more in terms of distance than of travel time.

Automobile ownership is only slightly significantly related to

TABLE 9

ALL INDUSTRIAL ZONES (LINEAR)

1. Multiple R = .547 F(2,2039) = 435. α = .0005 R^2 = .299

Variables	b	F(1,2039)	α
O_i	.00704	358.	.0005
D_j	.00596	373.	.0005

Constant -1.92

2. Multiple R = .665 F(3,2038) = 539. α = .0005 R^2 = .443

Variables	b	F(1,2038)	α
O_i	.00761	522.	.0005
D_j	.00612	756.	.0005
DIST	-.0642	524.	.0005

Constant 1.45

3. Multiple R = .658 F(3,2038) = 518. α = .0005 R^2 = .433

Variables	b	F(1,2038)	α
O_i	.00765	518.	.0005
D_j	.00660	853.	.0005
W TTIME	-.244	481.	.0005

Constant 1.53

TABLE 9 - Continued

4. Multiple R = .666 F(4,2037) = 405. α = .0005 R^2 = .443

Variables	b	F(1,2037)	α
O_i	.00767	516.	.0005
D_j	.00612	757.	.0005
DIST	-.0642	525.	.0005
AUTO	-1.62	1.36	.25

Constant 1.97

5. Multiple R = .666 F(5,2036) = 324. α = .0005 R^2 = .443

Variables	b	F(1,2036)	α
O_i	.00767	516.	.0005
D_j	.00613	754.	.0005
DIST	-.0642	525.	.0005
AUTO	-1.62	1.36	.25
PCOST	-.00083	.283	NOT SIG.

Constant 2.05

6. Multiple R = .667 F(4,2037) = 409. α = .0005 R^2 = .445

Variables	b	F(1,2037)	α
O_i	.00756	518.	.0005

TABLE 9 - Continued

D_j	.00605	738.	.0005
DIST	-.0634	511.	.0005
CHOICE MSPLIT	1.20	10.6	.005

Constant 1.41

7. Multiple R = .666 F(4,2037) = 407. α = .0005 R^2 = .444

Variables	b	F(1,2037)	α
O_i	.00762	525.	.0005
D_j	.00615	734.	.0005
DIST	-.0649	432.	.0005
TOTAL MSPLIT	-.806	5.85	.025

Constant 1.52

8. Multiple R = 6.80 F(4,2037) = 437. α = .0005 R^2 = .462

Variables	b	F(1,2037)	α
O_i	.00824	603.	.0005
D_j	.00590	719.	.0005
DIST	-.0616	495.	.0005
AUTOCAP MSPLIT	15.0	72.6	.0005

Constant .928

TABLE 9 - Continued

9. Multiple R = .688 F(5,2036) = 336. α = .0005 R^2 = .474

Variables	b	F(1,2036)	α
O_i	.00836	632.	.0005
D_j	.00595	746.	.0005
DIST	-.0636	534.	.0005
LOW RES	2.58	46.4	.0005
AUTOCAP MSPLIT	14.6	70.2	.0005

Constant -1.27

10. Multiple R = .687 F(5,2036) = .364 α = .0005 R^2 = .472

Variables	b	F(1,2036)	α
O_i	.00834	628.	.0005
D_j	.00594	742.	.0005
DIST	-.0634	528.	.0005
MED RES	-2.64	39.9	.0005
AUTOCAP MSPLIT	14.7	70.9	.0005

Constant 1.29

TABLE 9 - Continued

11. Multiple $R = .685$ $F(5,2036) = 360.$ $\alpha = .0005$ $R^2 = .469$

Variables	b	F(1,2036)	α
O_i	.00831	620.	.0005
D_j	.00594	737.	.0005
DIST	-.0629	519.	.0005
HIGH RES	-10.5	29.1	.0005
AUTOCAP MSPLIT	14.6	69.6	.0005

Constant 1.07

work trips in all the industrial zones and it does not improve the model considerably. It has an unexpected inverse relationship to tripmaking in the industrial zones and is rather unstable in its relationship with tripmaking to separate industrial centers.

Parking cost at destination is not significant. This is consistent with the situation observed in the south east and north east industrial zones. Even though it appears slightly significant in the North west industrial zone it does not improve the model considerably.

The proportion of automobile captives in a zone is the best measure of transit accessibility. This is similar to the case in the north west and south east industrial zones. This may be reflecting the fact that these industrial zones are located in the surburbs and receive work trips from these surburbs where the proportion of workers who are automobile captives is greatest in the city. Choice modal split and total modal split are only slightly significant when all the industrial zones are considered together but in the north east industrial zone choice modal split is the best measure of transit accessibility.

All the land use density variables are significantly related to work trips made to all the industrial zones. The strong correlation between the proportion of residential land with low density and with medium density housing (r = -.95) and the fact that they have opposite signs in the models indicate that they are doing essentially the same thing. However, the model with the proportion of residential land with low density housing explains a higher amount of variation than the others.

Log transformation of the variables improves the models (Table 10). As in the linear form, O_i, D_j and distance are the major explanatory variables and other variables only improve the model very slightly. Automobile ownership ratio is significant at an α level of only .25 in

TABLE 10

ALL INDUSTRIAL ZONES MODELS (LOG TRANSFORMATIONS)

1. Multiple $R = .524$ $F(2,2039) = 385.$ $\alpha = .0005$ $R^2 = .274$

Variables	b	F(1,2039)	α
Log of O_i	.396	356.	.0005
Log of D_j	.633	471.	.0005

Constant -2.23

2. Multiple $R = .669$ $F(3,2038) = 551.$ $\alpha = .0005$ $R^2 = .448$

Variables	b	F(1,2039)	α
Log of O_i	.453	601.	.0005
Log of D_j	.676	703.	.0005
Log of DIST	-.638	642.	.0005

Constant -1.40

3. Multiple $R = .650$ $F(3,2038) = 498.$ $\alpha = .0005$ $R^2 = .423$

Variables	b	F(1,2038)	α
Log of O_i	.453	574.	.0005
Log of D_j	.725	758.	.0005
Log of W TTIME	-.741	525.	.0005

Constant -1.74

TABLE 10 - Continued

4. Multiple R = .670 $F(4,2037) = 414.$ $\alpha = .0005$ $R^2 = .449$

Variables	b	F(1,2037)	α
Log of O_i	.459	576.	.0005
Log of D_j	.677	704.	.0005
Log of DIST	-.638	643.	.0005
Log of AUTO	-.0956	1.43	.25

Constant -1.46

5. Multiple R = .672 $F(5,2036) = 335.$ $\alpha = .0005$ $R^2 = .451$

Variables	b	F(1,2036)	α
Log of O_i	.460	583.	.0005
Log of D_j	.698	703.	.0005
Log of DIST	-.642	652.	.0005
Log of AUTO	-.099	1.55	.25
Log of PCOST	-.0756	10.2	.005

Constant -1.38

TABLE 10 - Continued

6. Multiple $R = .671$ $F(4,2037) = 418.$ $\alpha = .0005$ $R^2 = .451$

Variables	b	F(1,2037)	α
Log of O_i	.454	607.	.0005
Log of D_j	.698	702.	.0005
Log of DIST	-.642	651.	.0005
Log of PCOST	-.0751	10.1	.005

Constant -1.31

the logarithmic form while parking cost which is not significant in the linear form becomes significant at an α level of .005 in the logarithmic form.

6.8 COMBINATION OF THE FOUR EMPLOYMENT CENTERS

Table 11 presents the results of the models obtained when the four employment centers, namely, the Central Business District, the South east, North west and North east industrial zones are considered together. O_i and D_j are the major explanatory variables and either distance or weighted travel time equally improve the model slightly. However these measures of spatial separation are not as significant when all work trips in the city are considered as they are when separate industrial zones, or all the industrial zones are considered.

Automobile ownership ratio at origin is only slightly significant (α = .10) and it does not improve the model considerably. Parking cost at destination is not even significant when all work trips in the city are considered.

The measures of transit accessibility are not important in explaining work trips in the whole city. Choice modal split is significant at the low α level of .25, total modal split is not significant, and although the proportion of automobile captives in a zone is significant at a high α level of .05 it does not improve the model.

All the land use density variables fail to be significantly related to work trips when these four centers are considered together although at least one of them is important when separate employment centers are considered.

Table 12 indicates that the logarithmic transformation of the

TABLE 11

COMBINATION OF THE FOUR EMPLOYMENT CENTERS (LINEAR)

1. Multiple R = .781 F(2,3084) = 2049. α = .0005 R^2 = .610

Variables	b	F(1,3084)	α
O_i	.0212	1185.	.0005
D_j	.00647	3980.	.0005

Constant -8.40

2. Multiple R = .793 F(3,3083) = 1738. α =.0005 R^2 = .628

Variables	b	F(1,3083)	α
O_i	.0216	1294.	.0005
D_j	.00621	3624.	.0005
DIST	-.0699	156.	.0005

Constant -4.55

3. Multiple R = .792 F(3,3083) = 1733. α = .0005 R^2 = .628

Variables	b	F(1,3083)	α
O_i	.0217	1300.	.0005
D_j	.00670	4323.	.0005
W TTIME	-.253	150.	.0005

Constant -4.52

TABLE 11 - Continued

4. Multiple $R = .793$ $F(4,3082) = 1305.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3082)	α
O_i	.0214	1239.	.0005
D_j	.00620	3671.	.0005
DIST	-.0703	157.	.0005
AUTO	4.06	2.80	.10

Constant -5.83

5. Multiple $R = .793$ $F(5,3081) = 1044.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3081)	α
O_i	.0215	1241.	.0005
D_j	.00620	1788.	.0005
DIST	-.0703	157.	.0005
AUTO	4.06	2.80	.10
PCOST	.00003	.002	NOT SIG.

Constant -5.83

TABLE 11 - Continued

6. Multiple $R = .793$ $F(5,3081) = 1045.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3081)	α
O_i	.0215	1241.	.0005
D_j	.00626	3234.	.0005
DIST	-.0709	159.	.0005
AUTO	4.08	2.83	.10
CHOICE MSPLIT	-.714	1.70	.25

Constant -5.79

7. Multiple $R = .793$ $F(5,3081) = 1044.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3081)	α
O_i	.0215	1237.	.0005
D_j	.00622	2891.	.0005
DIST	-.0706	156.	.0005
AUTO	3.91	2.54	.25
TOTAL MSPLIT	-.0709	.156	NOT SIG.

Constant -5.77

TABLE 11 - Continued

8. Multiple R = .793 F(5,3081) = 1046. α = .0005 R^2 = .629

Variables	b	F(1,3081)	α
O_i	.0218	1196.	.0005
D_j	.00620	3674.	.0005
DIST	-.0698	155.	.0005
AUTO	3.71	2.34	.25
AUTOCAP MSPLIT	5.64	3.98	.05

Constant -5.96

9. Multiple R = .793 F(6,3080) = 871. α = .0005 R^2 = .629

Variables	b	F(1,3080)	α
O_i	.0218	1190.	.0005
D_j	.00620	3670.	.0005
DIST	-.0703	152.	.0005
AUTO	3.43	1.89	.25
LOW RES	.363	.250	NOT SIG.
AUTOCAP MSPLIT	5.61	3.94	.05

Constant -6.16

TABLE 11 - Continued

10. Multiple R = .793 $F(6,3080) = 871.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3080)	α
O_i	.0218	1189.	.0005
D_j	.00620	3620.	.0005
DIST	-.0702	153.	.0005
AUTO	3.42	1.85	.25
MED RES	-.350	.188	NOT SIG.
AUTOCAP MSPLIT	5.62	3.96	.05

Constant -5.80

11. Multiple R = .793 $F(6,3080) = 871.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3080)	α
O_i	.0218	1196.	.0005
D_j	.00620	3672.	.0005
DIST	-.0702	154.	.0005
AUTO	3.81	2.45	.25
HIGH RES	-1.93	.292	NOT SIG.
AUTOCAP MSPLIT	5.57	3.88	.05

Constant -5.94

TABLE 12

COMBINATION OF THE FOUR EMPLOYMENT CENTERS (LOG TRANSFORMATIONS)

1. Multiple $R = .791$ $F(2,3084) = 2545.$ $\alpha = .0005$ $R^2 = .623$

Variables	b	F(1,3084)	α
Log of O_i	.557	1347.	.0005
Log of D_j	.840	4210.	.0005

Constant -3.18

2. Multiple $R = .825$ $F(3,3083) = 2191.$ $\alpha = .0005$ $R^2 = .681$

Variables	b	F(1,3083)	α
Log of O_i	.597	1802.	.0005
Log of D_j	.780	4417.	.0005
Log of DIST	-.491	560.	.0005

Constant -2.34

3. Multiple $R = .818$ $F(3,3083) = 2075.$ $\alpha = .0005$ $R^2 = .669$

Variables	b	F(1,3083)	α
Log of O_i	.604	1760.	.0005
Log of D_j	.898	5203.	.0005
Log of W TTIME	-.562	429.	.0005

Constant -2.79

TABLE 12 - Continued

4. Multiple R = .825 $F(4,3082) = 1647.$ $\alpha = .0005$ $R^2 = .681$

Variables	b	F(1,3082)	α
Log of O_i	.588	1639.	.0005
Log of D_j	.799	4410.	.0005
Log of DIST	-.496	567.	.0005
Log of AUTO	.148	5.77	.025

Constant -2.24

5. Multiple R = .825 $F(5,3081) = 1318.$ $\alpha = .0005$ $R^2 = .681$

Variables	b	F(1,3081)	α
Log of O_i	.588	1641.	.0005
Log of D_j	.812	2431.	.0005
Log of DIST	-.498	568.	.0005
Log of AUTO	.149	5.81	.025
Log of PCOST	-.0196	1.39	.25

Constant -2.23

variables improve the models, and increases the level of significants of automobile ownership ratio and parking cost at destination but they do not increase the amount of variation explained by the models considerably.

6.9 COMBINATION OF THE FOUR EMPLOYMENT CENTERS WITH EACH DESTINATION AREA SPECIFIED

All work trips to the four employment centers considered together, first with two dummy variables indicating whether a work trip was destined to the Central Business District or to any of the three industrial zones. The results of the regressions obtained in this approach which are shown in Appendix VI (e) seems to indicate that locational factors are not important in explaining work tripmaking in the city. However, the models obtained are similar to those presented in Table 13 in which four dummy variables indicating whether a work trip was destined to the Central Business District, South east industrial zones, North west industrial zones or North east industrial zones are used.

The dummy variables are not significant in most models and they do not improve on the models obtained in the previous section. In fact the level of explanation of the models remains exactly the same as their equivalents for work tripmaking in Table 11. It is interesting to note that the low level of significance may not necessarily indicate that the variables are not important in explaining some amount of variation. O_i, D_j and distance remain the major explanatory variables while automobile ownerhip ratio, measures of transit accessibility and land use density variables all fail to improve the models. In the logarithmic form (Table 14), the amount of variation explained remained basically the same as in their equivalents in Table 12.

TABLE 13

COMBINATION OF THE FOUR EMPLOYMENT CENTERS WITH EACH DESTINATION AREA SPECIFIED (LINEAR)

1. Multiple R = .781 $F(5,3081) = 963.$ $\alpha = .0005$ $R^2 = .610$

Variables	b	F(1,3081)	α
O_i	.0212	1185.	.0005
D_j	.00642	1318.	.0005
D1	-.207	.137	NOT SIG.
D2	-.254	.228	NOT SIG.
D3	.107	.023	NOT SIG.

Constant -8.21

2. Multiple R = .793 $F(6,3080) = 870.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3080)	α
O_i	.0216	1294.	.0005
D_j	.00645	1397.	.0005
DIST	-.0720	159.	.0005
D1	.920	2.80	.10
D2	.969	3.37	.10
D3	.705	1.08	NOT SIG.

Constant -5.37

TABLE 13 - Continued

3. Multiple $R = .792$ $F(6,3080) = 866.$ $\alpha = .0005$ $R^2 = .628$

Variables	b	F(1,3080)	α
O_i	.0217	1300.	.0005
D_j	.00657	1438.	.0005
W TTIME	-.254	150.	.0005
D1	-.523	.923	NOT SIG.
D2	-.445	.732	NOT SIG.
D3	-.477	.491	NOT SIG.

Constant -4.01

4. Multiple $R = .793$ $F(7,3079) = 747.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3079)	α
O_i	.0214	1239.	.0005
D_j	.00645	1398.	.0005
DIST	-.0724	160.	.0005
AUTO	4.07	2.81	.10
D1	.928	2.85	.10
D2	.972	3.39	.10
D3	.732	1.16	NOT SIG.

Constant -6.66

TABLE 13 - Continued

5. Multiple R = .793 F(8,3078) = 653. α = .0005 R^2 = .629

Variables	b	F(1,3078)	α
O_i	.0214	1238.	.0005
D_j	.00640	1172.	.0005
DIST	-.0724	160.	.0005
AUTO	4.03	2.7	.10
PCOST	.00057	.446	NOT SIG.
D1	1.00	3.19	.10
D2	1.10	3.84	.05
D3	.825	1.41	.25

Constant -6.78

6. Multiple R = .793 F(7,3079) = 746. α = .0005 R^2 = .629

Variables	b	F(1,3079)	α
O_i	.0216	1295.	.0005
D_j	.00646	1396.	.0005
DIST	-.0723	160.	.0005
CHOICE MSPLIT	-.520	.856	NOT SIG.
D1	.821	2.15	.25
D2	.865	2.57	.25
D3	-.520	.734	NOT SIG.

Constant -5.24

TABLE 13 - Continued

7. Multiple R = .793 F(7,3079) = 745. α = .0005 R^2 = .629

Variables	b	F(1,3079)	α
O_i	.0216	1293.	.0005
D_j	.00646	1362.	.0005
DIST	-.0722	158.	.0005
TOTAL MSPLIT	-.0578	.103	NOT SIG.
D1	.892	2.56	.25
D2	.939	3.07	.10
D3	.676	.970	NOT SIG.

Constant -5.33

8. Multiple R = .793 F(7,3079) = 747. α = .0005 R^2 = .629

Variables	b	F(1,3079)	α
O_i	.0219	1252.	.0005
D_j	.00643	1388.	.0005
DIST	-.0715	156.	.0005
AUTOCAP MSPLIT	5.67	4.02	.05
D1	.877	2.54	.25
D2	.899	2.89	.10
D3	.637	.877	NOT SIG.

Constant -5.55

TABLE 13 - Continued

9. Multiple $R = .793$ $F(8,3078) = 654.$ $\alpha = .0005$ $R^2 = .630$

Variables	b	F(1,3078)	α
O_i	.0219	1253.	.0005
D_j	.00644	1389.	.0005
DIST	-.0724	155.	.0005
AUTOCAP MSPLIT	5.57	3.89	.05
LOW RES	.638	.812	NOT SIG.
D1	.891	2.62	.25
D2	.941	2.99	.10
D3	.636	.873	NOT SIG.

Constant -6.07

10. Multiple $R = .793$ $F(8,3078) = 654.$ $\alpha = .0005$ $R^2 = .630$

Variables	b	F (1,3078)	α
O_i	.0219	1253.	.0005
D_j	.00644	1388.	.0005
DIST	-.0724	155.	.0005
AUTOCAP MSPLIT	5.59	3.91	.05
MED RES	-.689	.784	NOT SIG.
D1	.889	2.61	.25
D2	.913	2.98	.10
D3	.636	.872	NOT SIG.

Constant -5.44

TABLE 13 - Continued

11. Multiple $R = .793$ $F(8,3078) = 653.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3078)	α
O_i	.0219	1251.	.0005
D_j	.00644	1388.	.0005
DIST	-.0719	154.	.0005
AUTOCAP MSPLIT	5.61	3.94	.05
HIGH RES	-1.72	.233	NOT SIG.
D1	.884	2.58	.25
D2	.907	2.94	.10
D3	.639	.879	NOT SIG.

Constant -5.52

TABLE 14

COMBINATION OF THE FOUR EMPLOYMENT CENTERS WITH EACH DESTINATION AREA SPECIFIED (LOG TRANSFORMATIONS)

1. Multiple R = .792 $F(5,3081) = 1037.$ $\alpha = .0005$ $R^2 = .627$

Variables	b	F(1,3081)	α
Log of O_i	.558	1363.	.0005
Log of D_j	.733	936.	.0005
D1	-.132	32.8	.0005
D2	-.113	26.7	.0005
D3	-.0887	8.70	.005

Constant -2.79

2. Multiple R = .826 $F(6,3080) = 1099.$ $\alpha = .0005$ $R^2 = .682$

Variables	b	F(1,3080)	α
Log of O_i	.596	1798.	.0005
Log of D_j	.753	1153.	.0005
Log of DIST	-.483	526.	.0005
D1	-.0625	8.42	.005
D2	-.0392	3.67	.10
D3	-.0509	3.34	.10

Constant -2.18

TABLE 14 - Continued

3. Multiple R = .821 $F(6,3080) = 1057.$ $\alpha = .0005$ $R^2 = .673$

Variables	b	F(1,3080)	α
Log of O_i	.604	1781.	.0005
Log of D_j	.790	1220.	.0005
Log of W TTIME	-.562	433.	.0005
D1	-.135	38.9	.0005
D2	-.108	28.0	.0005
D3	-.100	12.5	.0005

Constant -2.40

4. Multiple R = .826 $F(7,3079) = 944.$ $\alpha = .0005$ $R^2 = .682$

Variables	b	F(1,3079)	α
Log of O_i	.588	1637.	.0005
Log of D_j	.752	1153.	.0005
Log of DIST	-.488	533.	.0005
Log of AUTO	.146	5.63	.025
D1	-.062	8.30	.005
D2	-.039	3.64	.10
D3	-.050	3.27	.10

Constant -2.08

TABLE 14 - Continued

5. Multiple $R = .826$ $F(8,3078) = 827.$ $\alpha = .0005$ $R^2 = .682$

Variables	b	F(1,3078)	α
Log of O_i	.588	1639.	.0005
Log of D_j	.764	1063.	.0005
Log of DIST	-.488	534.	.0005
Log of AUTO	.148	4.73	.025
Log of PCOST	-.0344	2.42	.25
D1	-.0680	9.68	.005
D2	-.0602	6.00	.025
D3	-.0618	4.61	.05

Constant -2.04

The use of dummy variables indicating direct location fails to improve the models. This may be due to the fact that all major employment centers receive work trips from all parts of the city. Although the attracting ability of other major centers is secondary to that of the Central Business District, their work trip demand is much lower than that of the CBD with the result that direct locational factor is not important. It is therefore suggested that the effect of the quality of the location, which may be a more appropriate measure, should be investigated.

This chapter has discussed the models obtained from the different aggregates of origin-destination pairs of work trips to the major employment centers in Edmonton. The manner in which the variables contribute significantly to the statistical explanation of the observed pattern of work trips have been noted. The discussion of the results obtained from some of these models are presented in Chapter VII.

CHAPTER VII

DISCUSSION OF RESULTS

7.1 VERIFICATION OF THE MODELS

In order to assess the reliability of the models obtained in the analysis, the predicted number of work trips using some of the models obtained in the analysis is compared with the actual trips made. Figure 19 is obtained by graphically plotting the observed values against the predicted values between Traffic Zones using the best linear model developed for the South east industrial zones. A good linear fit is not obtained, most trips are over-predicted and the correlation coefficient between observed and predicted values is only .67. Similar conditions are observed with regard to the North east industrial zones (r = .57) and the North west industrial zones (r = .35). This may be due to the predominance of small number of trips (in some cases only 1 or 2 trips) between origin-destination pairs of zones. In the Central Business District, the plotting of observed values against predicted values has a wide scatter, indicating that these models do not perform well when work trips between Traffic zones are compared.

Most statistical models require that in order to obtain valid results a large number of observations should be used since this increases the confidence limits of the results. Aggregation of values obtained according to Traffic Districts gives a larger number to work with and is a better approach to comparing the observed and predicted values of work trips to the employment centers in the city. But there is a limit to the amount of improvement that can be obtained from aggregation. The Traffic District number is obtained by dropping the low order digit from the Traffic Zone number and the 234 Traffic Zones in the area of study result in 58 Traffic Districts (Figure 20).

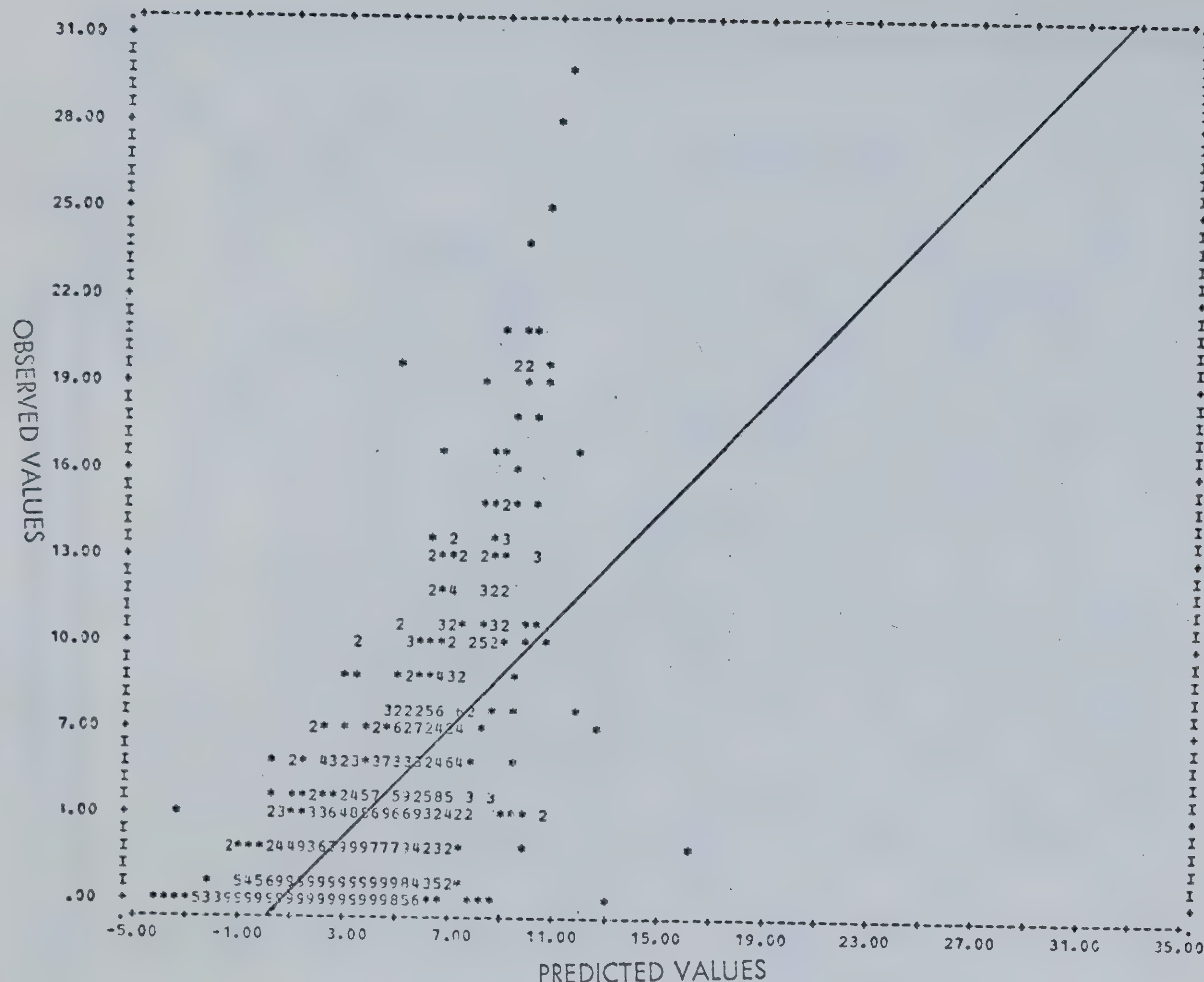

FIG. 19 OBSERVED VERSUS PREDICTED VALUES FOR WORK TRIPS TO THE SOUTH EAST USING THE BEST LINEAR MODEL IN THE SOUTH EAST INDUSTRIAL ZONES

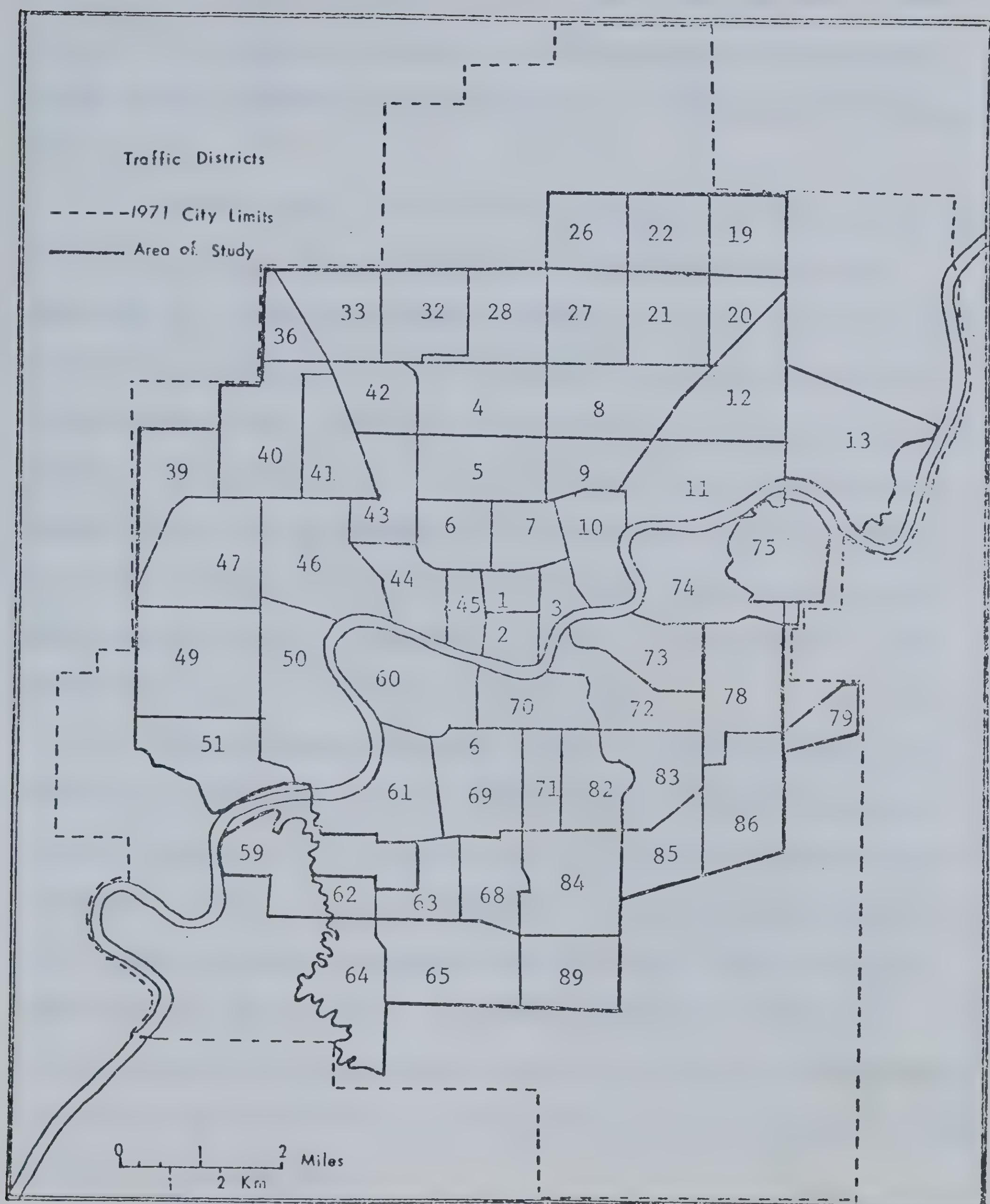

FIG. 20 TRAFFIC DISTRICTS IN EDMONTON

7.2 CHOICE OF MODELS TESTED

A systematic approach is used in selecting the models tested. This approach attempts to indicate how the reliability of the models change as more variables are introduced and increasing spatial definition is achieved.

Since O_i and D_j are important explanatory variables in all the employment centers, the models obtained from them are tested first (Model No. 1). Distance, which is a measure of spatial separation which contributes significantly to explaining work tripmaking, especially in the industrial zones. Therefore models tested next (Model No. 2) takes distance into consideration. The introduction of variables related to accessibility, land use density and socio-economic variables improved the models slightly, especially in the industrial zones, so the best linear models (Model No. 3 in each industrial zone and Model No. 4 in the Central Business District) are also tested.

Since the models developed from O_i, D_j and DIST explain considerable variation and are only slightly improved by the introduction of more variables it is the most meaningful model and is further tested in different forms. The model developed from O_i, D_j and DIST when the three industrial zones are combined together is now applied to each industrial zone (Model No. 4). The model obtained from these same variables when the four employment centers in the city are combined is also applied to each center in order to assess its performance in different areas (Model No. 5).

Finally, since logarithmic transformation of the variables increased the variation explained, the logarithm form of Model No. 1

(O_i, D_j) and Model No. 2 (O_i, D_j, DIST) are tested as Models 6 and 7 respectively.

The models are applied to work trips to each employment center, the resulting predicted values are aggregated according to Traffic Districts and are then compared with their observed equivalents. The results obtained from the testing of these models are presented in Appendix VII.

7.3 GRAPHICAL COMPARISON OF OBSERVED AND PREDICTED VALUES

As a means of testing the performance of the models, the observed values are plotted against the predicted values in each Traffic District using the results obtained from testing the models and the amount of scatter from the line along which predicted values are exactly equal to observed values is noted. Such a graphical comparison reveals the model that gives the best linear fit.

Figures 21 - 27 present the plotting of the observed values against predicted values of work trips to the Central Business District using the results from models tested. Traffic districts generating less than 20 trips in the CBD not included in the plotting since the models predict them poorly. All the models give a good linear fit, and the correlation between observed and predicted values are consistently high (over .90 in all cases except in Figure 25 (Model No. 5)). In fact, all the subsequent models (Figures 22 - 27) fail to improve significantly on the pattern of linear fit obtained from Model No. 1 (Figure 21), since O_i and D_j are the major explanatory variables of work trips made to the Central Business District. Thus generation and attractiveness of the CBD explain work tripmaking to the district while the introduction of

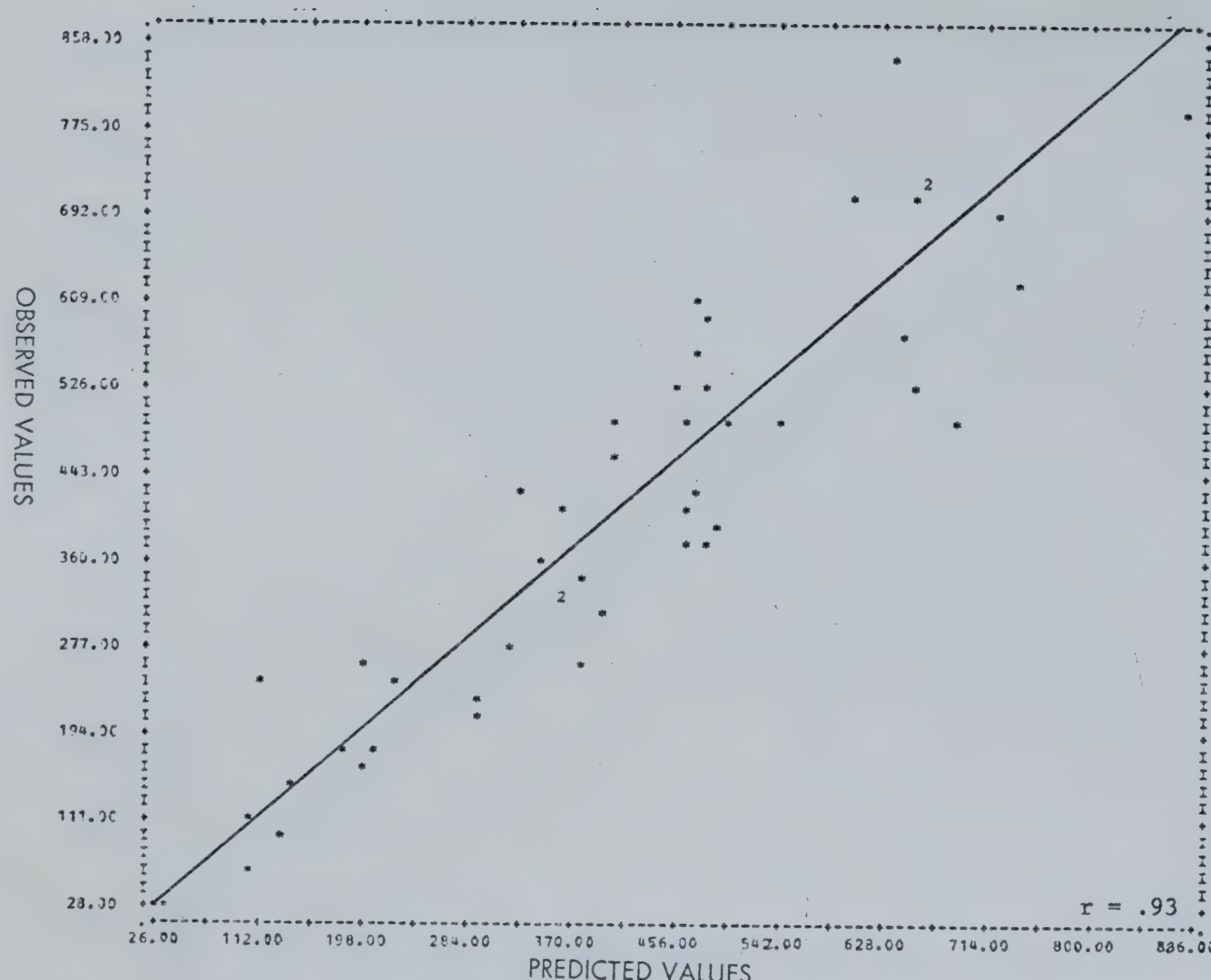

FIG. 21 OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO.1

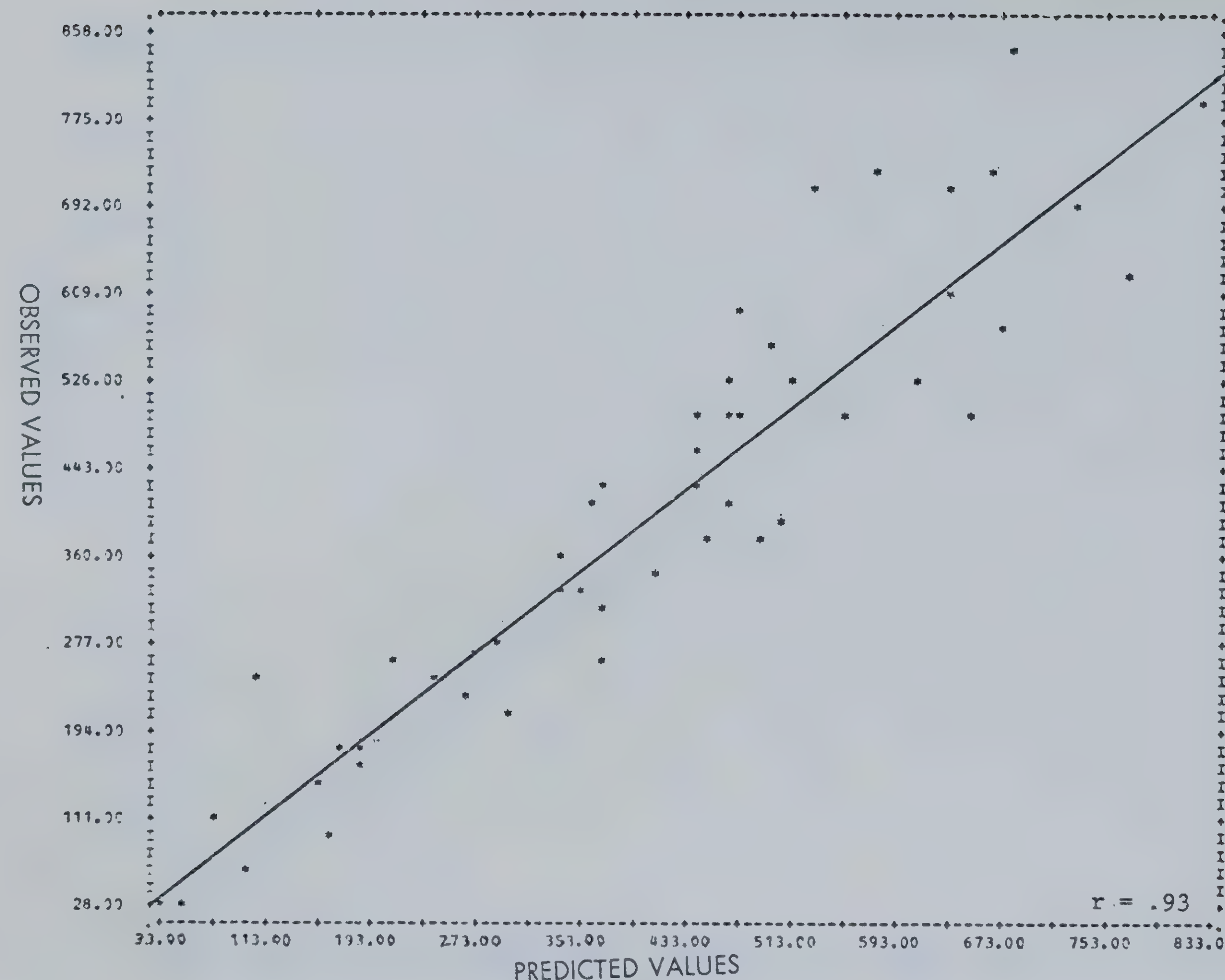

FIG. 22 OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO. 2

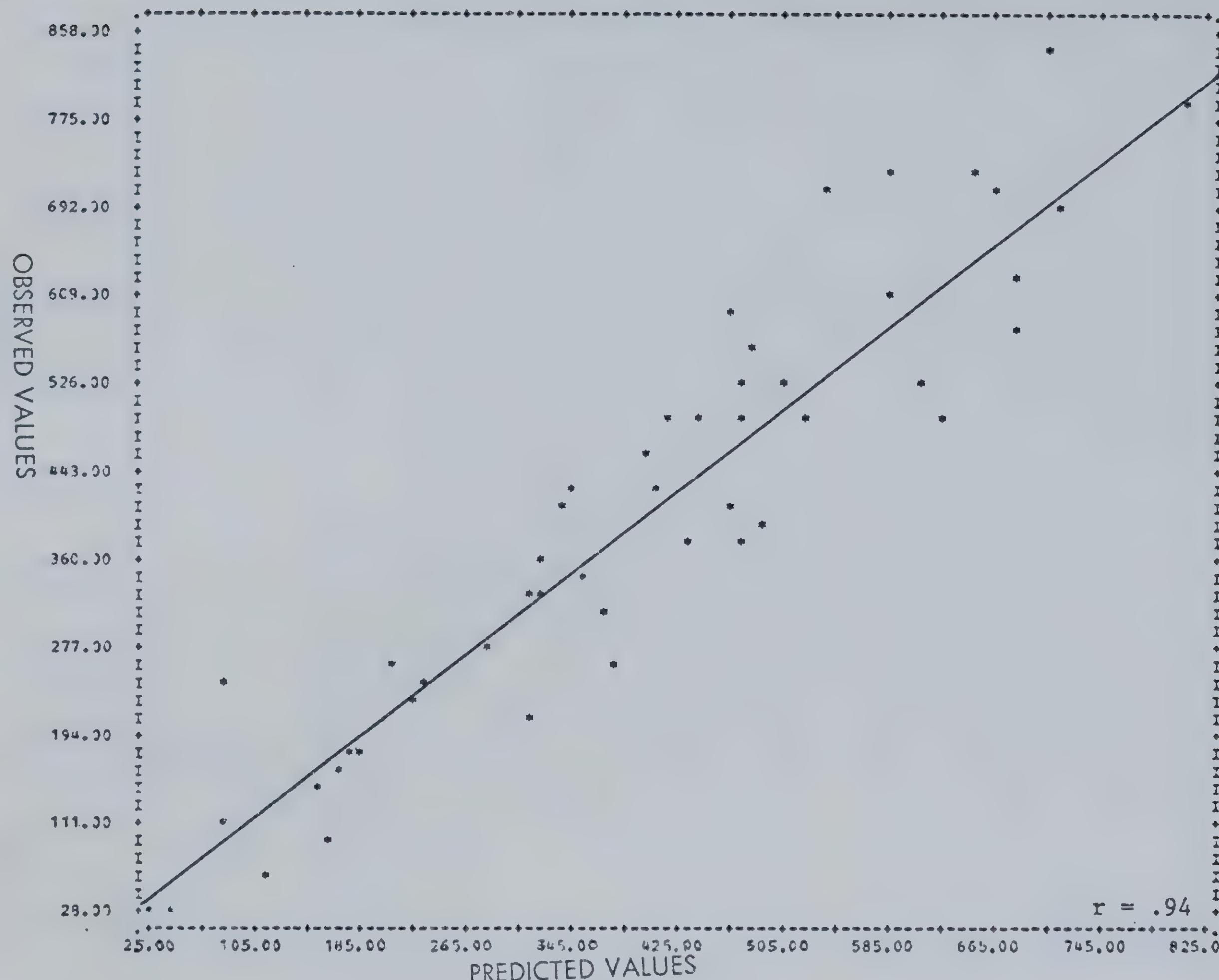

FIG. 23 OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO. 3

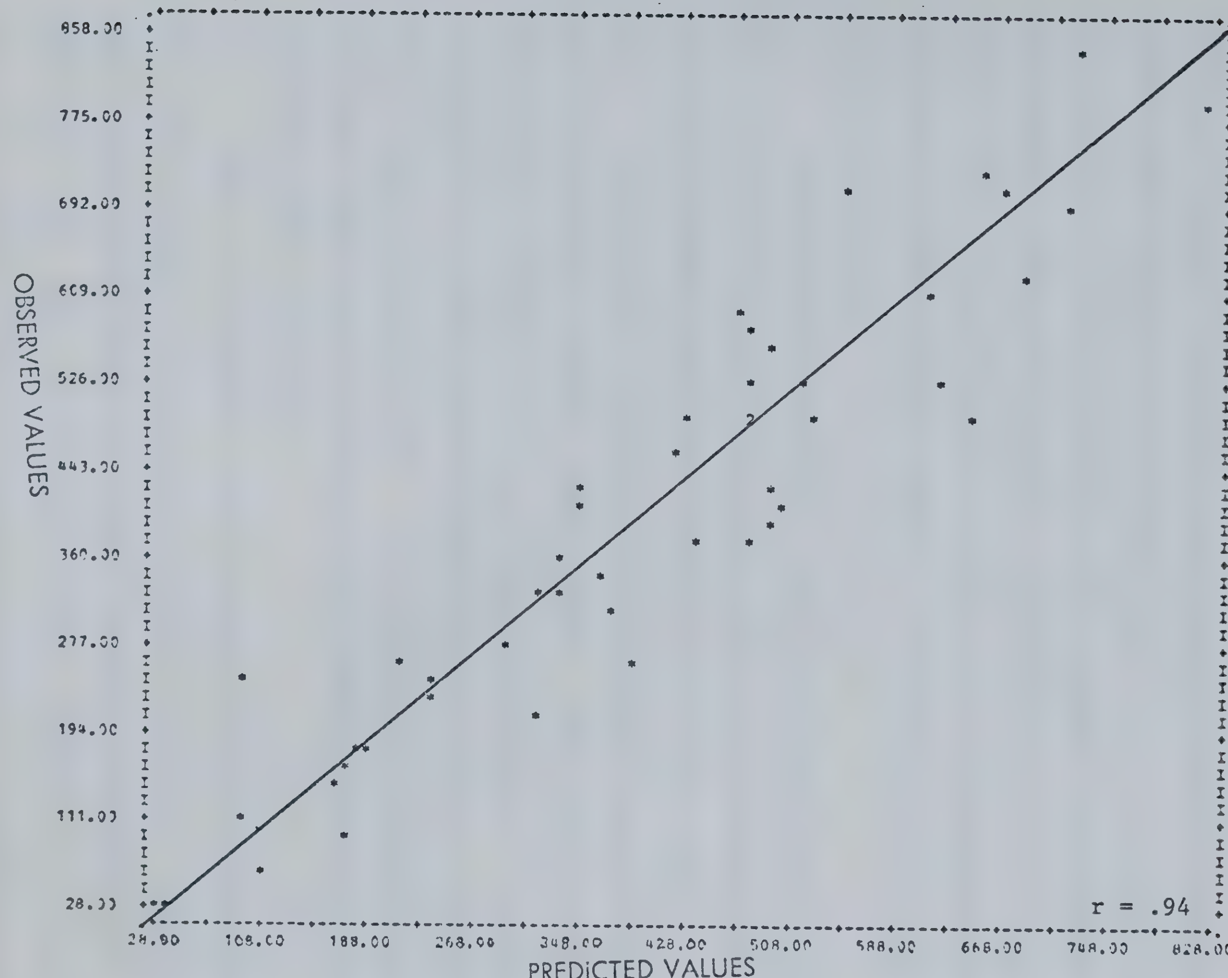

FIG. 24 OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO. 4

other variables related to work tripmaking do not have any significant impact.

It is interesting to note that Model No. 5 obtained by combining the four employment centers works reasonably well in the Central Business District, Figure 25. This is explained by the fact that the CBD is the single largest attractor of work trips in the city. It is however surprising that the models obtained from the logarithmic transformation of the variables which performs better in the analysis, fail to be significantly better than the linear models when used in this aggregated form for prediction (Figure 26 and Figure 27). There may not be any simple explanation for this.

In terms of the total work trips to the Central Business District, these models perform almost equally well since the percentage of over prediction and under prediction is less than 10% in most cases.

The general trend in the industrial zones is fairly comparable since they have fairly similar characteristics. The results obtained for the South east industrial zones are presented in Figures 28 - 34 while those for the North west industrial zones and the North east industrial zones are shown in Appendix VIII. Traffic districts generating less than 10 trips in these industrial zones are not considered in the plotting since the models predict them poorly.

Model No. 1 results in small volumes of trips being over-predicted while large volumes of trips are under-predicted, Figure 28. The zones in which trips are under-predicted are those nearest to the South east industrial zones. The same situation exists in the North west and the North east industrial zones, and results from the fact that these industrial zones receive the highest proportion of work trips originating in these zones immediately around them. When distance is taken into consideration in Model No. 2 a better linear fit is obtained (Figure 29), since the

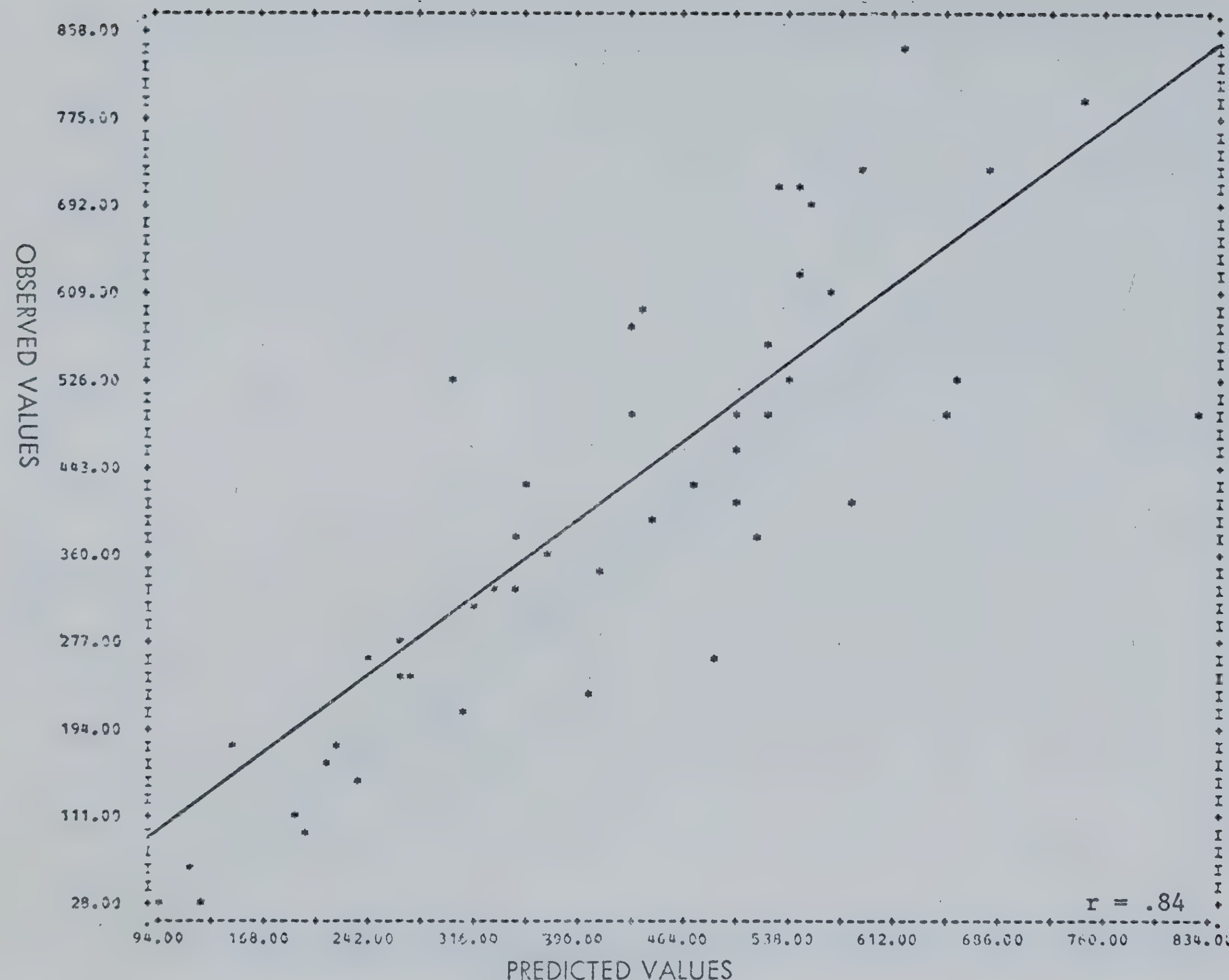

FIG. 25 OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO. 5

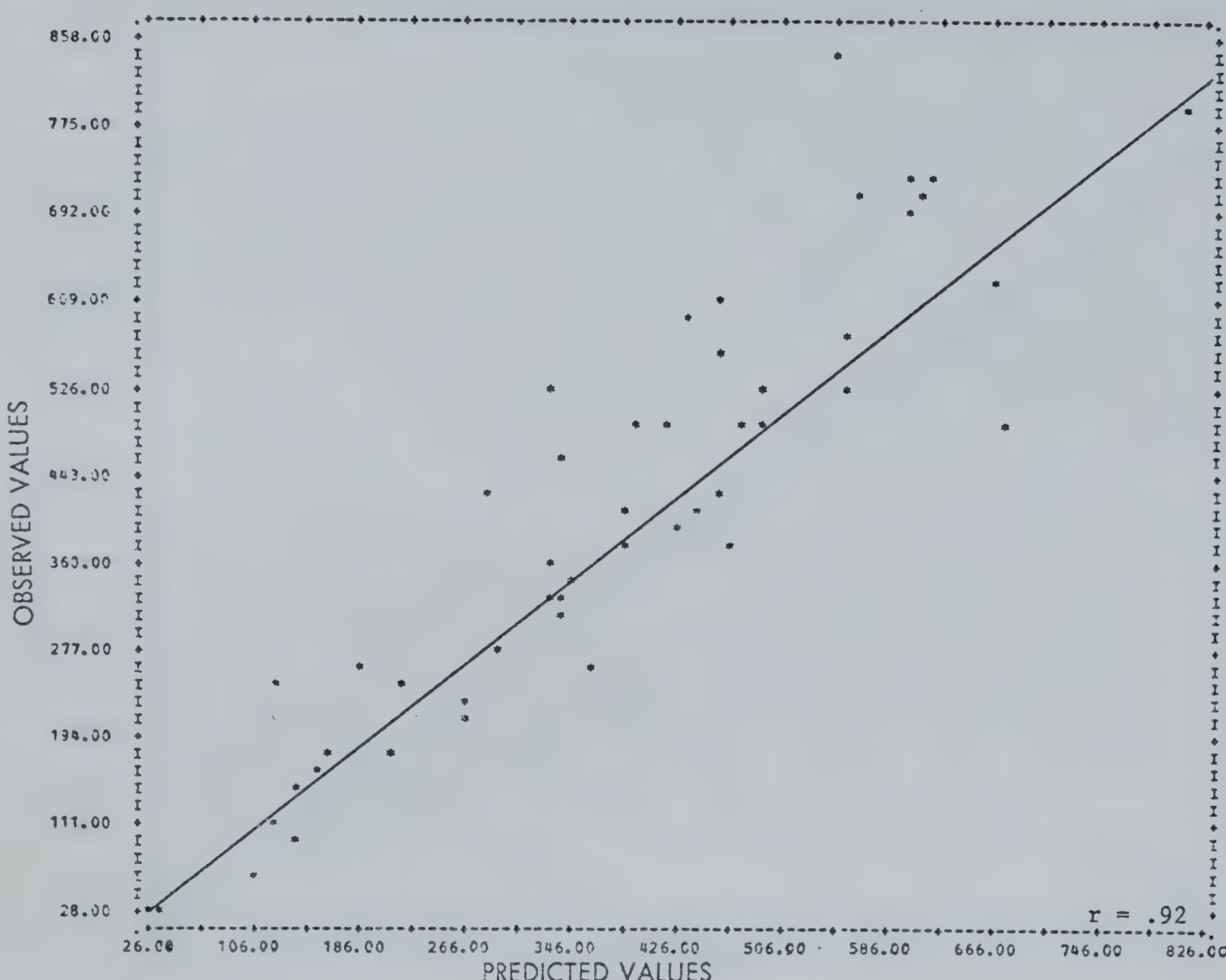

FIG. 26 OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO. 6

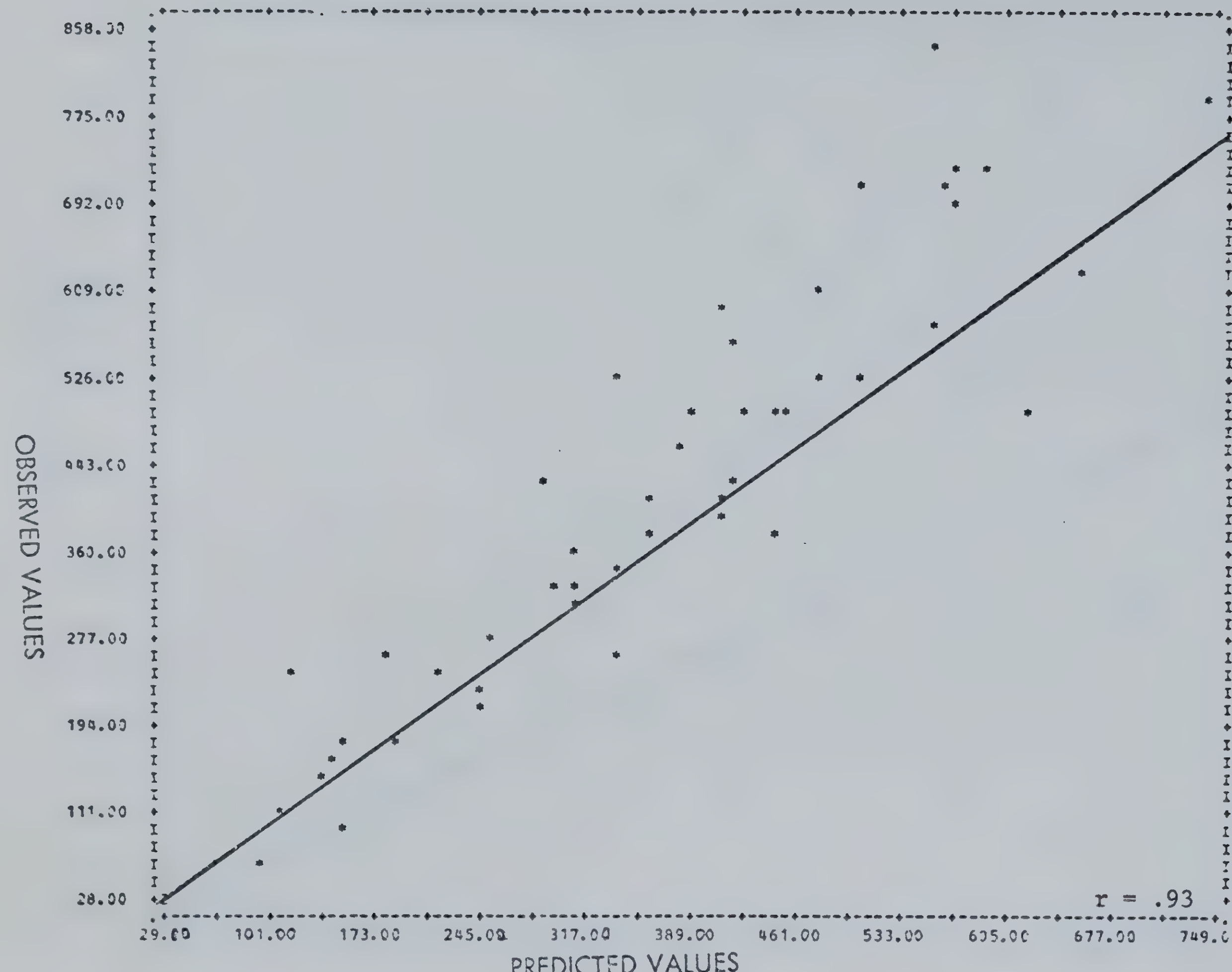

FIG. 27 OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO.7

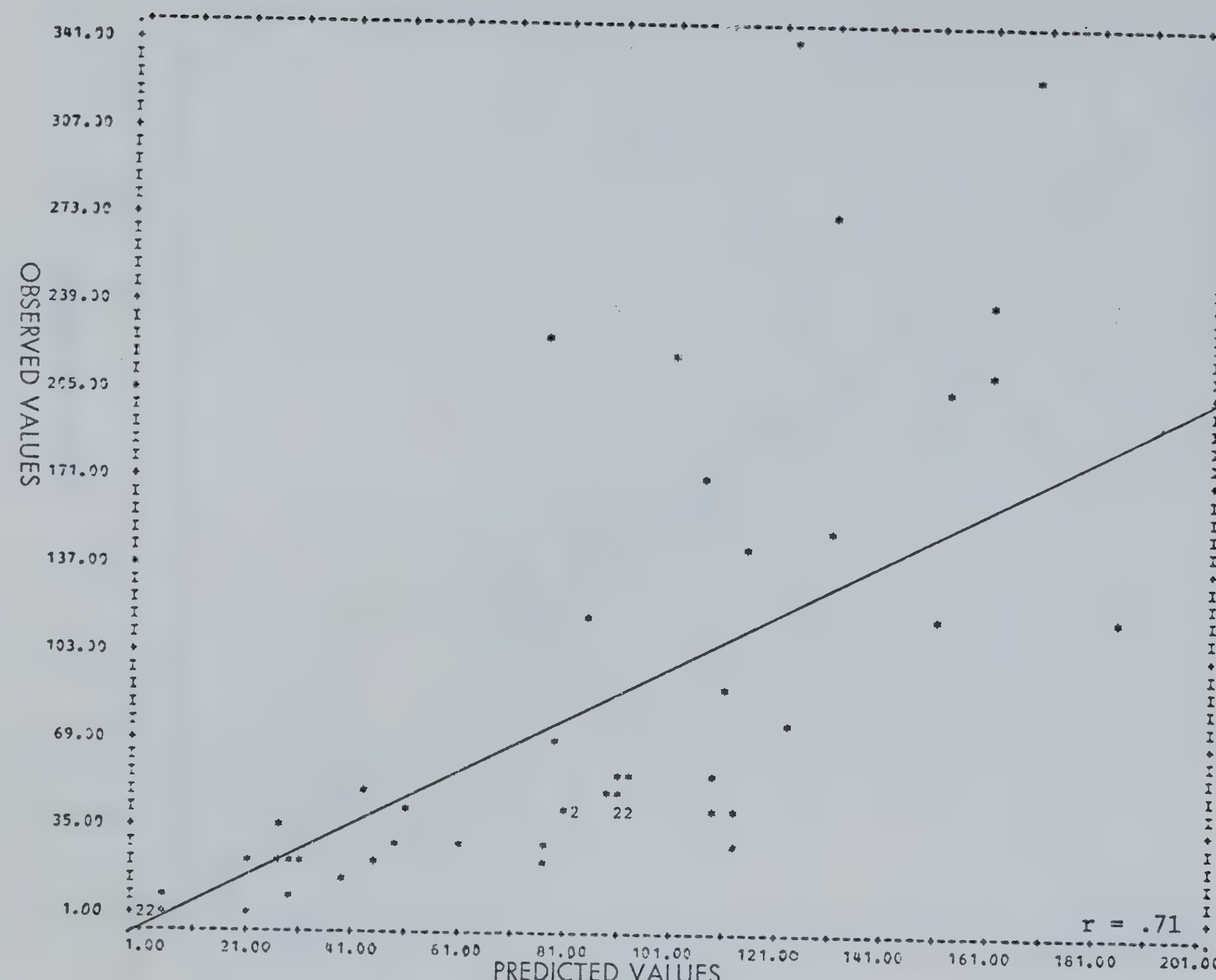

FIG. 28 OBSERVED VERSUS PREDICTED VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO. 1

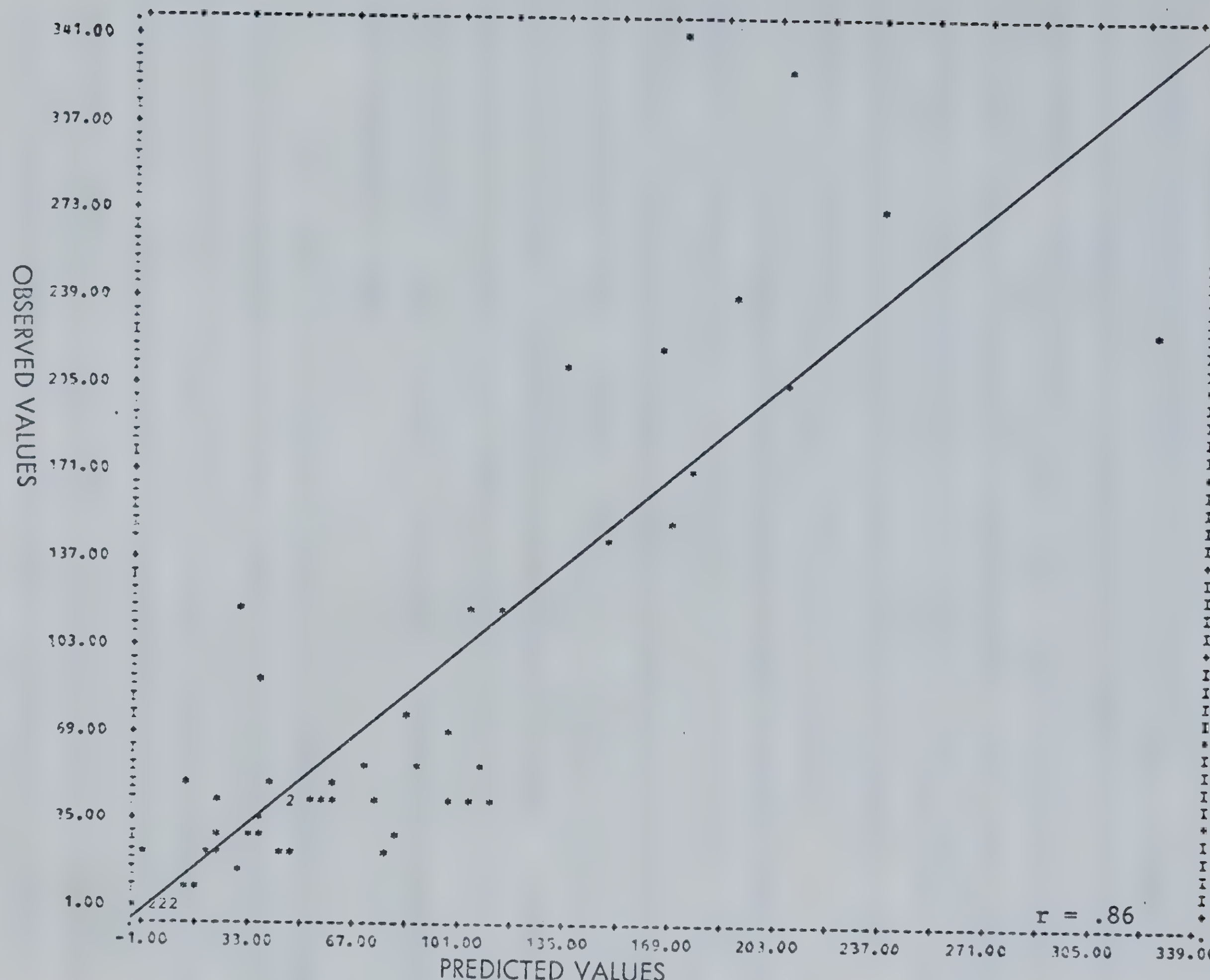

FIG. 29 OBSERVED VERSUS PREDICTED VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO. 2

distance-decay effect observed in the spatial pattern of work trip attraction is now incorporated.

Model No. 3 which is the best linear model slightly improves the linear fit between the observed and predicted values. Figure 30 obtained from aggregation according to Traffic Districts is a considerable improvement on Figure 19 which was based on Traffic Zones indicating that the models perform better on the aggregated scale. The slight improvement from this model show that the variables related to land use density and accessibility are capturing small effects on travel demand to these industrial zones which O_i, D_j and DIST have not captured.

Since these industrial zones have fairly similar characteristics, Model No. 4 developed from a combination of the three of them, performs reasonably well in the South east industrial zones (Figure 31) and the other industrial zones. However, unlike in the Central Business District, Model No. 5 performs very poorly in these industrial zones. Its poor performance in the South east industrial zone is depicted in Figure 32. This may be due to the relatively fewer number of work trips attracted to these industrial zones.

The logarithmic transformation of the variables improve slightly on the result obtained from the linear form in the South east industrial zones (Figures 33 and 34) and also in the other industrial zones. It is rather strange that this situation is also observed in the North west industrial zones since the logarithmic transformation of the variables failed to increase the level of explanation in the original regression.

In terms of total work trips to these industrial zones, the linear models perform better than the logarithmic models which grossly under-predict total tripmaking to the industrial zones.

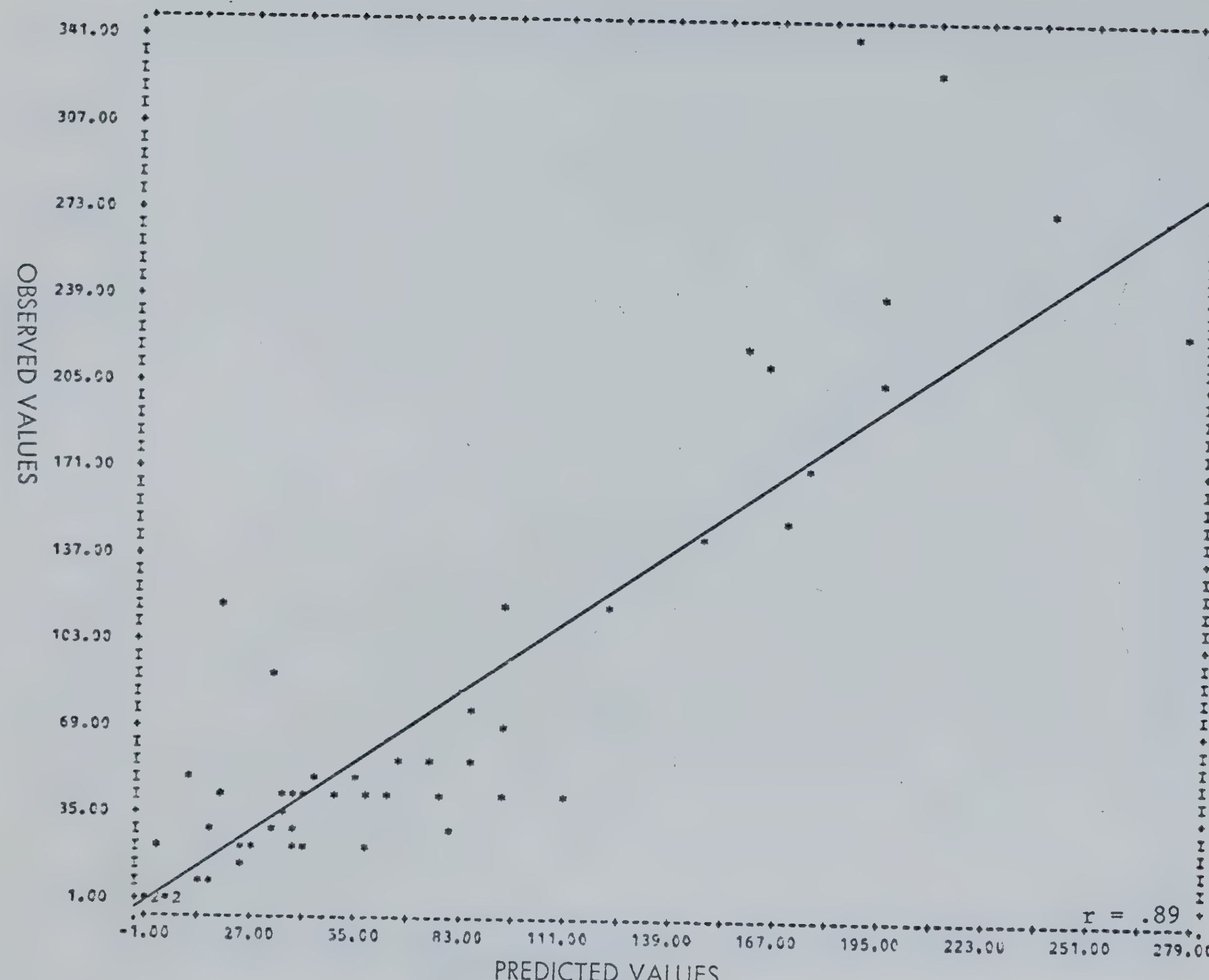

FIG. 30 OBSERVED VERSUS PREDICTED VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO. 3

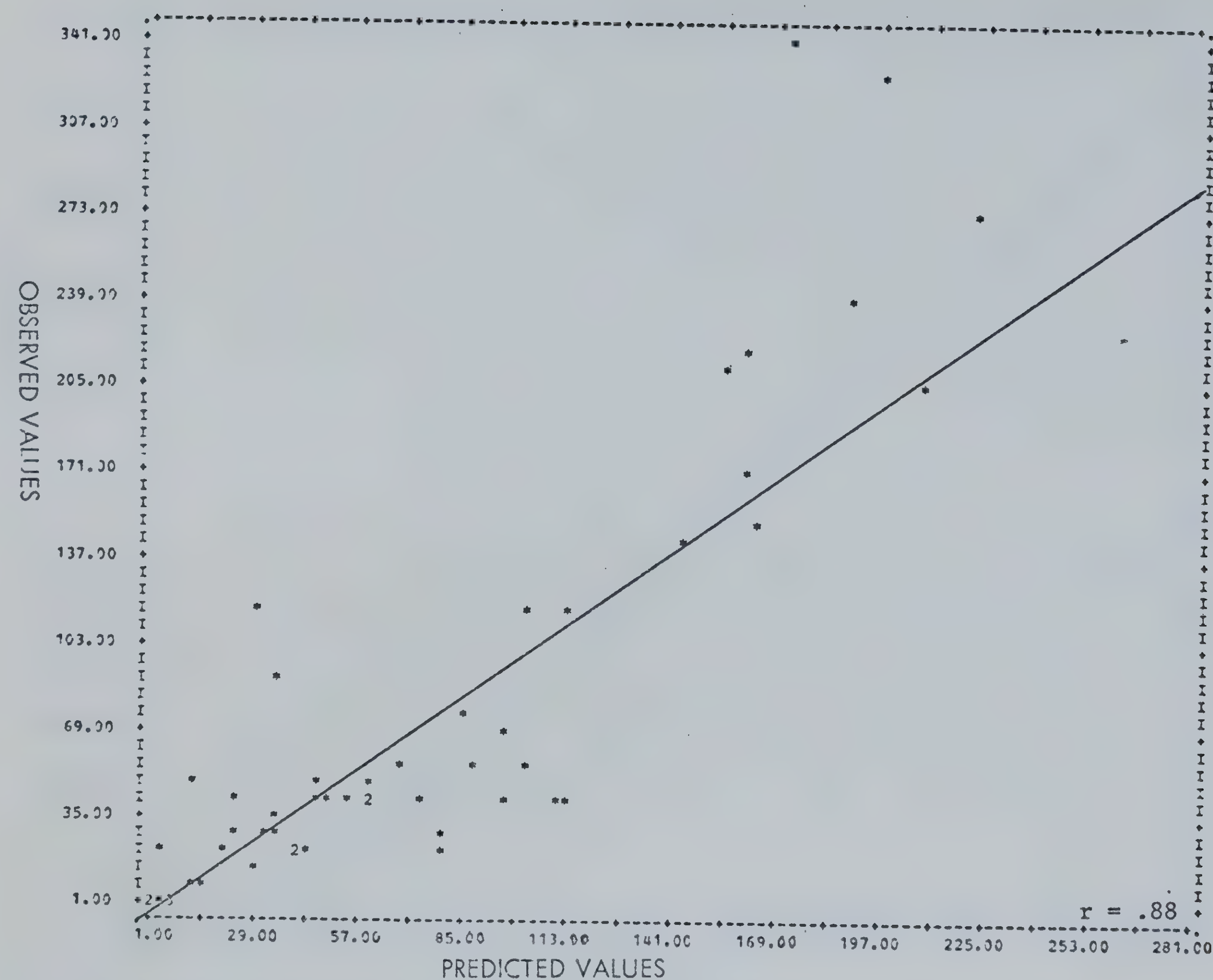

FIG. 31 OBSERVED VERSUS PREDICTED VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO. 4

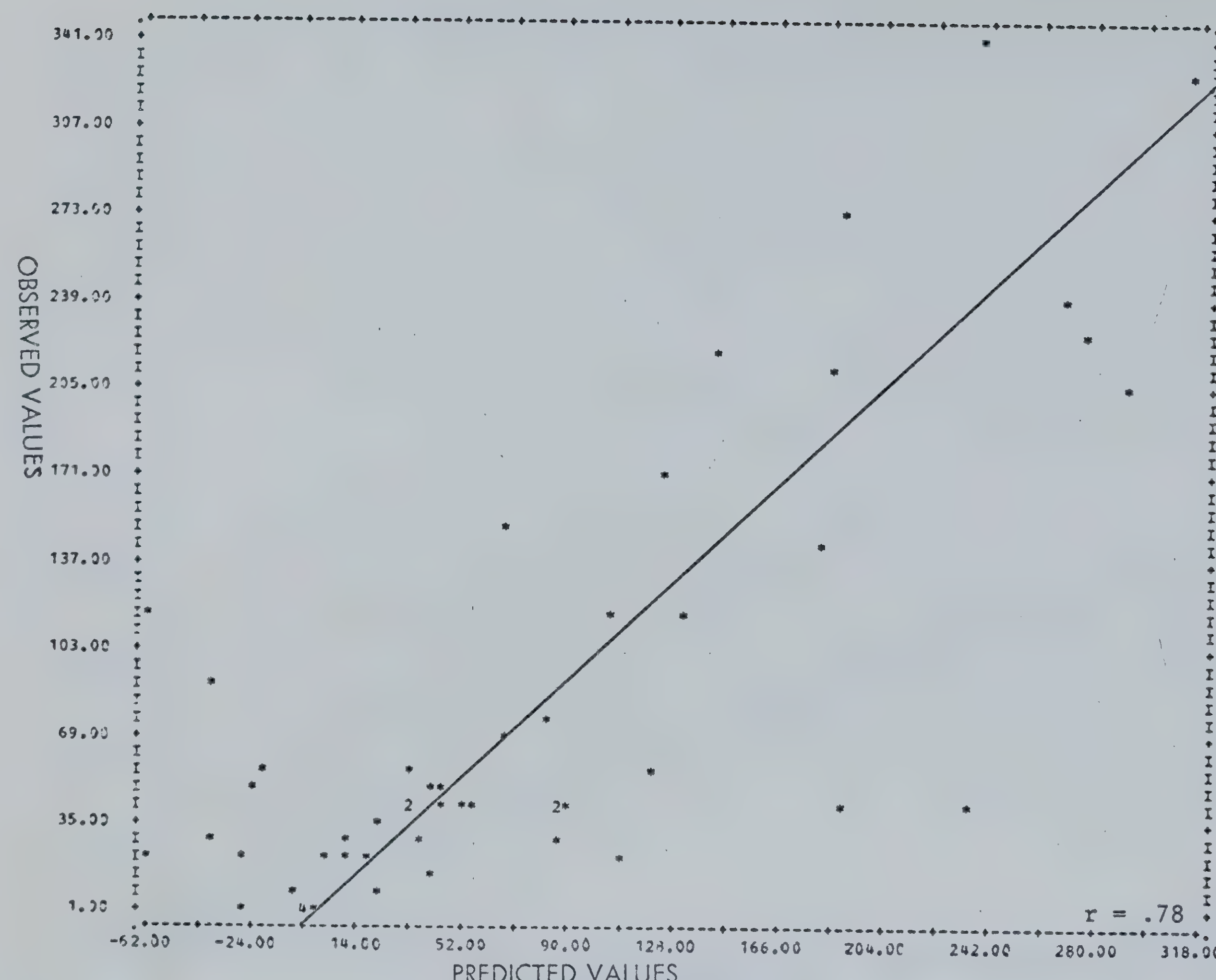

FIG. 32 OBSERVED VERSUS PREDICTED VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO. 5

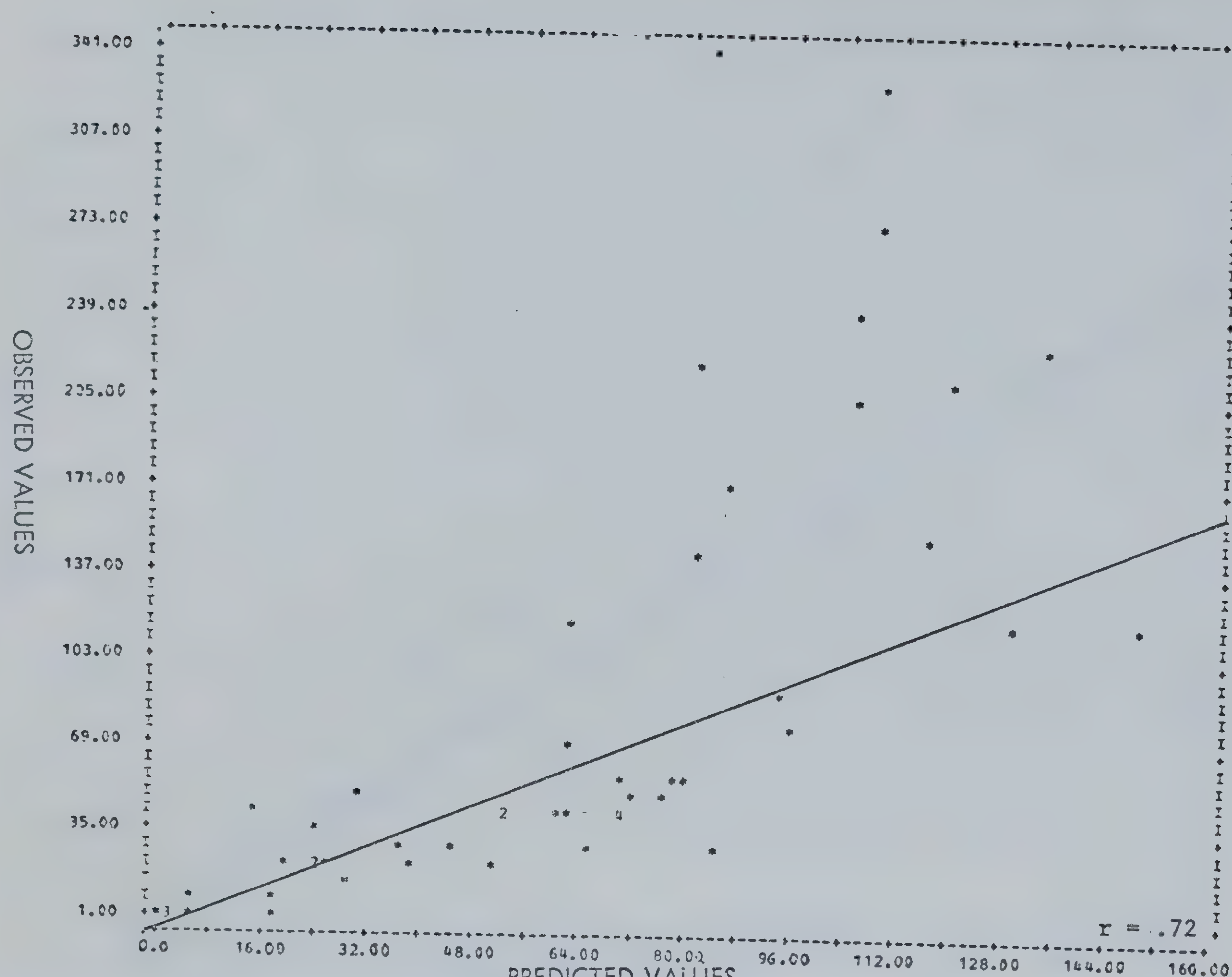

FIG. 33 OBSERVED VERSUS PREDICTED VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO. 6

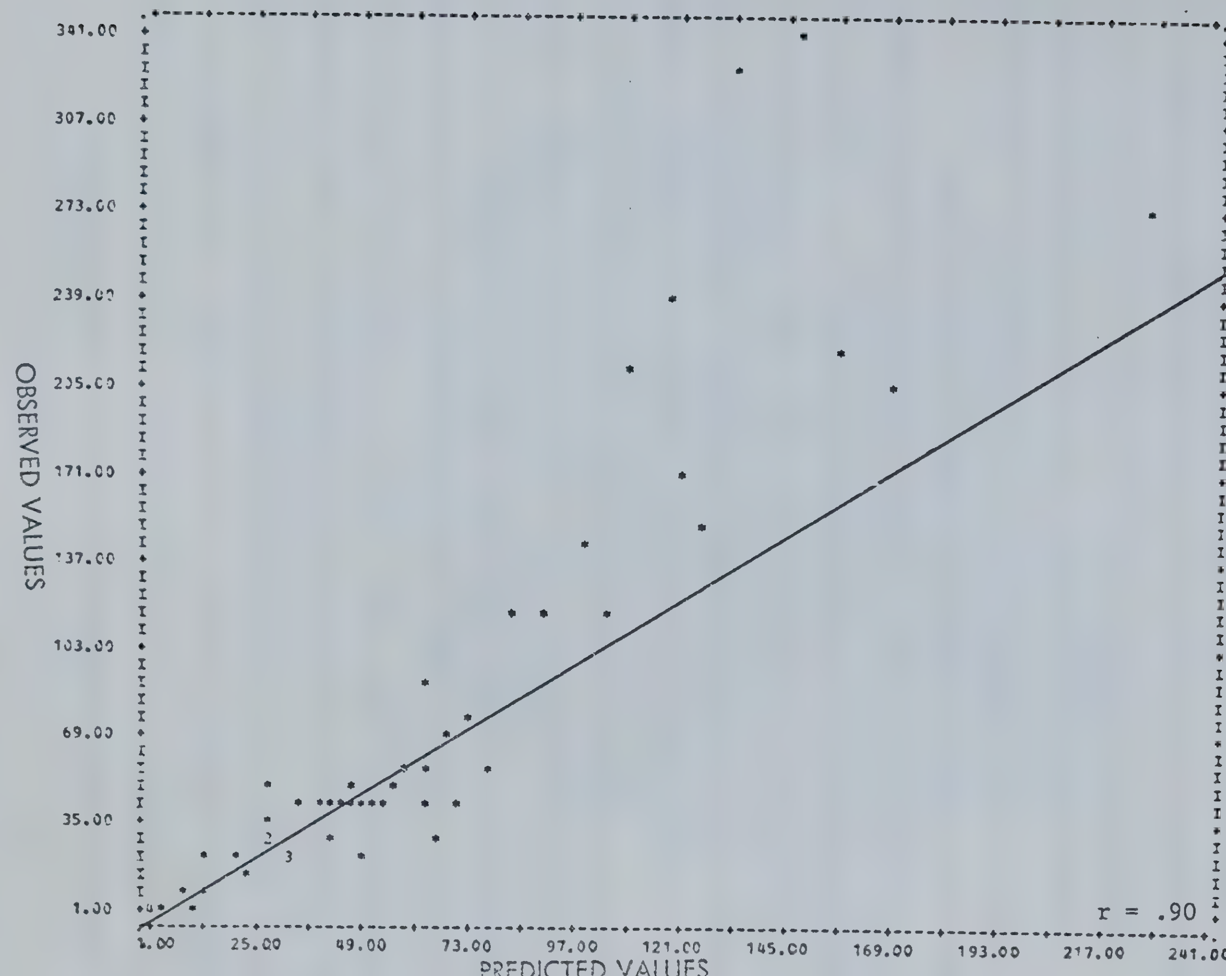

FIG. 34 OBSERVED VERSUS PREDICTED. VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO.7

7.4 DISTRIBUTION OF RESIDUALS BY TRAFFIC DISTRICTS

In order to assess the pattern of distribution of the results from these models, the difference between observed and predicted values (i.e. residuals are calculated for Traffic District) are obtained. Then the percentage of under-prediction or over-prediction is mapped in order to investigate whether any spatial pattern exists in the prediction. The results obtained from the testing of Models 1 and 2 in the Central Business District and Model No. 3 in each industrial zone are used.

Figure 35 shows that Model No. 1 tends to grossly under-predict work trips made from the Traffic Districts immediately around the Central Business District. Figure 36 shows that Model No. 2 removes the gross under-prediction in these areas but does not improve on the pattern of prediction in the other districts in the city for work trips to the CBD. Figure 37 shows that the Model No. 3 predicts exactly in only two Traffic Districts in the city but does not have any consistent trend of over or under-prediction in the rest of the city. Although there seems to be a core-periphery bias in the distribution of residuals for the industrial zones the trend is not highly emphasized. Figure 38 plots the spatial distribution of residuals from the best linear model for the North west industrial zones. Although there is the tendency for the model to under-predict in zones near this employment center and to over-predict in zones further away from it, this trend is not distinct. Figure 39 indicates that a similar situation is observed in the North east industrial zones.

Therefore, there is no easily recognizable pattern in which these residuals are distributed.

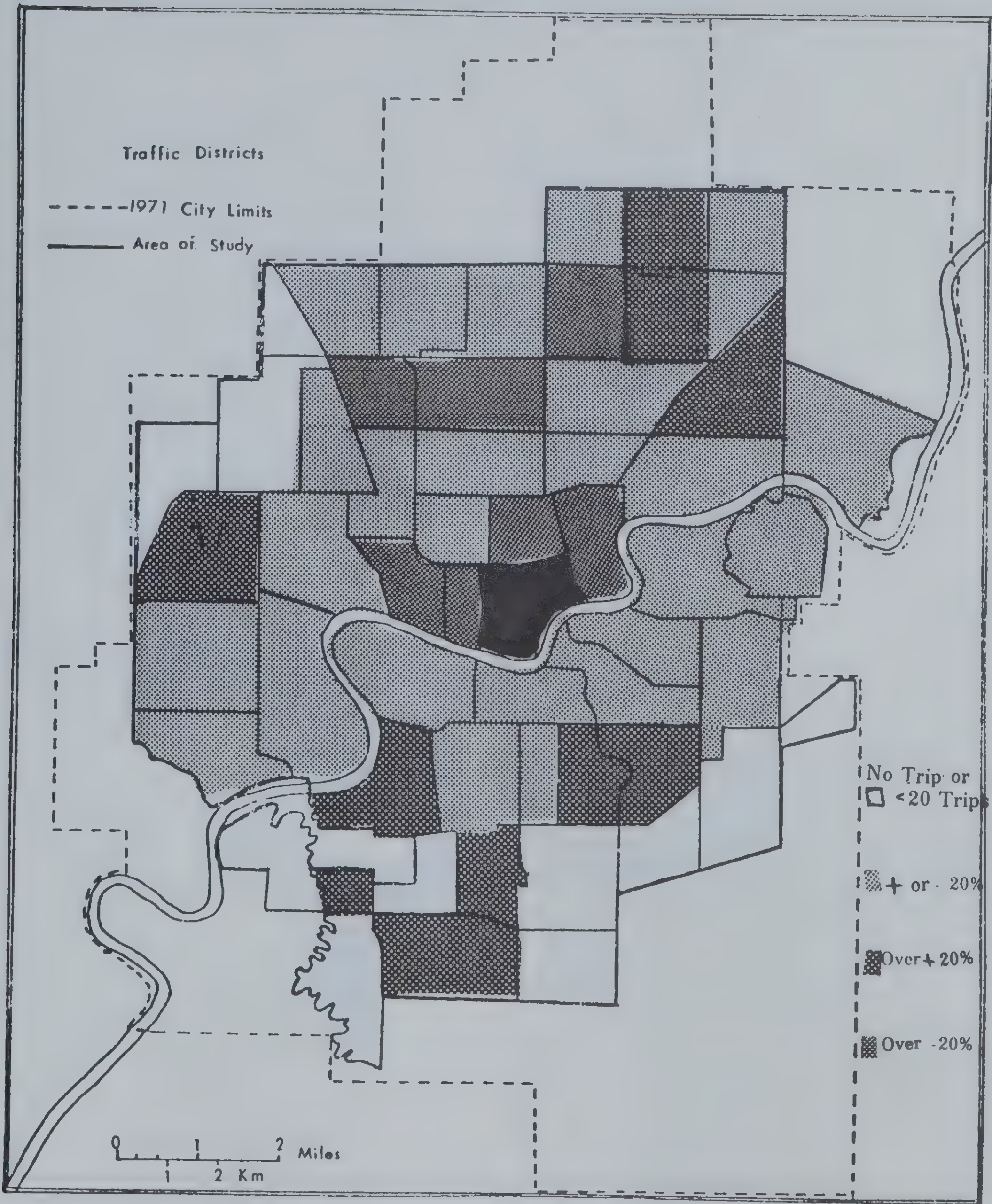

FIG. 35 SPATIAL DISTRIBUTION OF OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO. 1

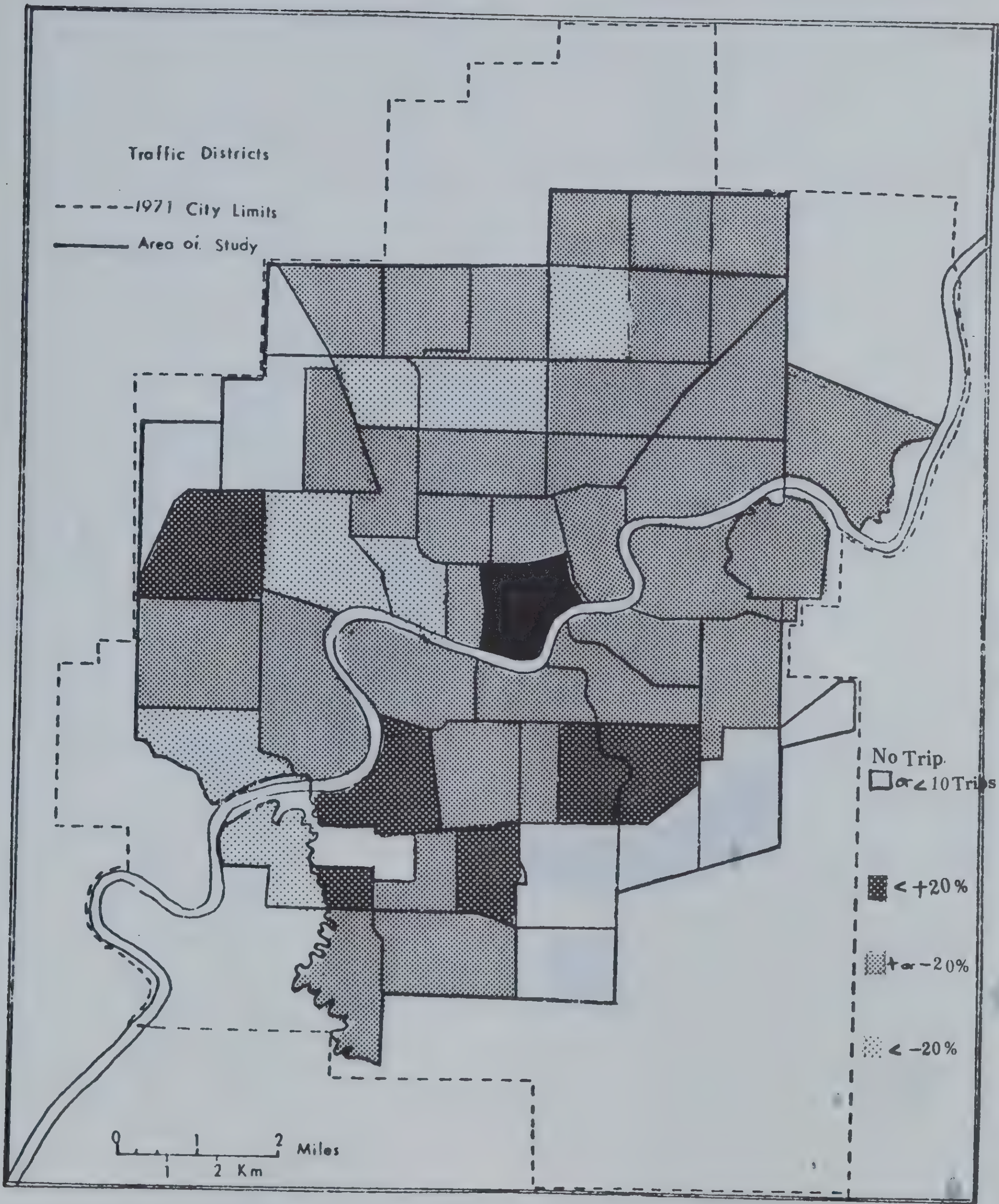

FIG. 36 SPATIAL DISTRIBUTION OF OBSERVED VERSUS PREDICTED VALUES FOR THE CENTRAL BUSINESS DISTRICT USING MODEL NO. 2

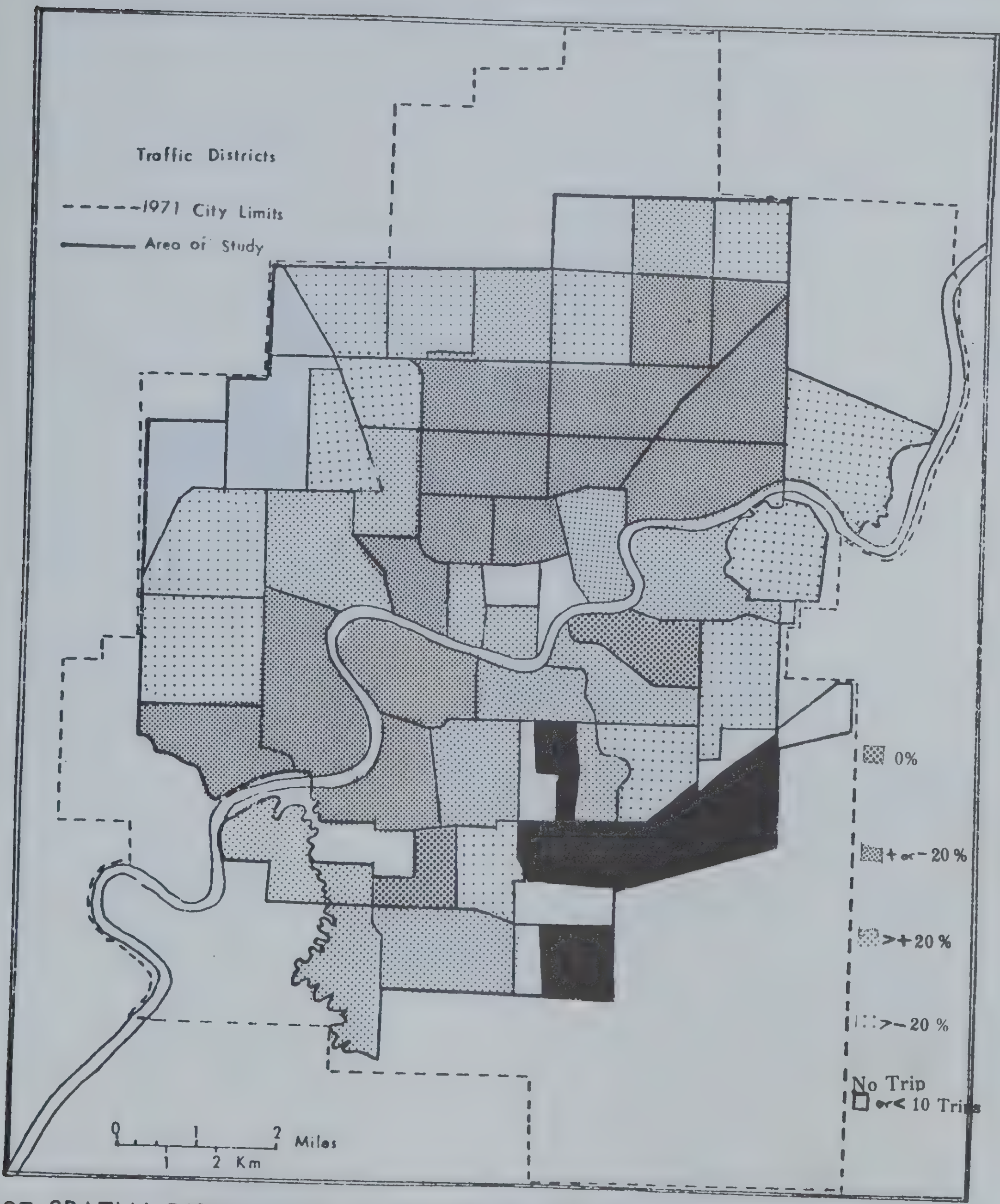

FIG.37 SPATIAL DISTRIBUTION OF OBSERVED VERSUS PREDICTED VALUES FOR THE SOUTH EAST INDUSTRIAL ZONES USING MODEL NO. 3

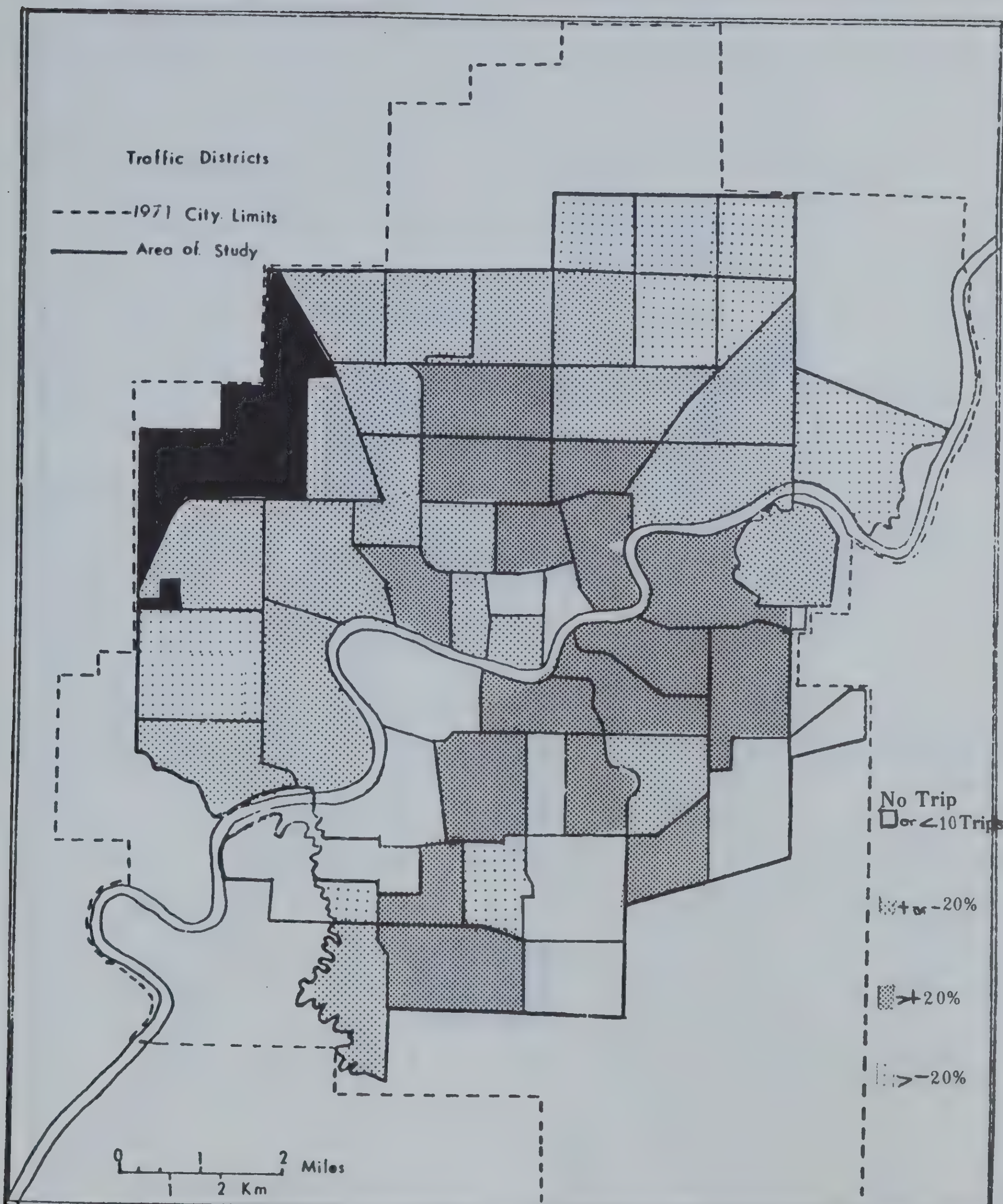

FIG. 38 SPATIAL DISTRIBUTION OF OBSERVED VERSUS PREDICTED VALUES FOR NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 3

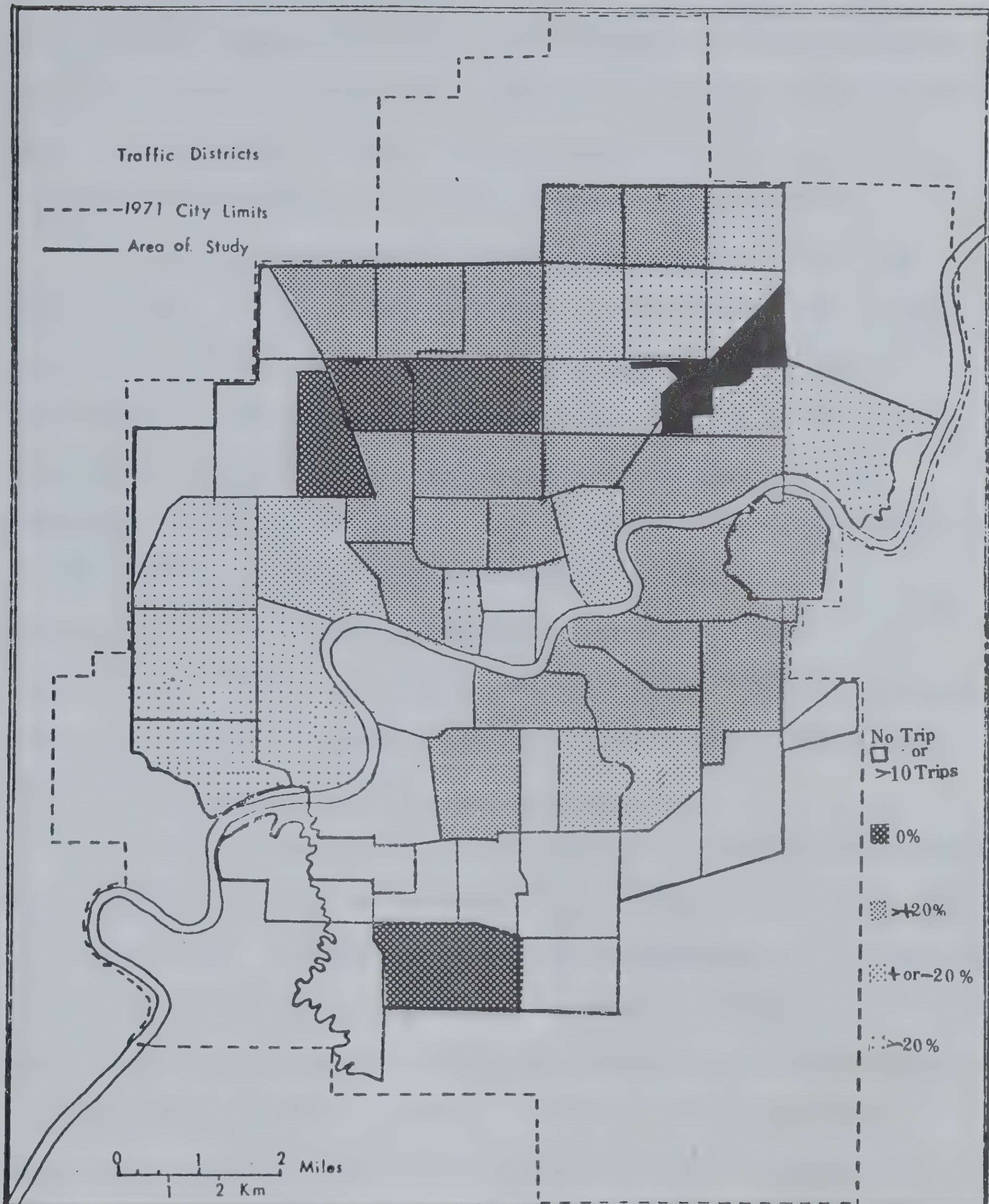

FIG. 39 SPATIAL DISTRIBUTION OF OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST INDUSTRIAL ZONES USING MODEL NO. 3

7.5 SUMMARY OF FINDINGS FROM THE RESULTS

The testing of the models obtained in the analysis using Traffic zones by aggregating these values according to Traffic districts has revealed that these models are relatively stable since the observed trends are comparable. It has also been noted that there is a limit to the amount of improvement that can be obtained from aggregation.

In the Central Business District the intensity of work trip generation (O_i) and the attractive ability of the district are the major factors that determine the pattern of work trips made to the district since Model No. 1 performs well in predicting work trips to the district. The distance variable may have been indirectly incorporated in the generation factor, and the introduction of models incorporating measures of accessibility, land use density and socio-economic variables fail to improve the linear fit and the prediction obtained from model No. 1 considerably. Even the logarithmic form of Model No. 1 fail to improve prediction. Model No. 5 performs well in the Central Business District since it is the major employment center in the city.

In the industrial zones Model No. 2 is the most meaningful model and it predicts the trips to the traffic districts most reasonably. However, as in the analysis, the Model No. 3 incorporating measures of accessibility and land use density improves prediction slightly. The similarity of these zones is still emphasized by the fact that Model No. 4 works well in all the industrial zones while Model No. 5 does not. As in the analysis, logarithmic form of the models perform slightly better in prediction.

7.6 SUGGESTIONS FOR FURTHER WORK

1. The results obtained from testing these models indicate that they

perform better on the aggregated scale of Traffic Districts than on the smaller scale of Traffic Zones. The use of Traffic Districts results in larger numbers and reduces the fluctuation associated with smaller numbers or fewer trips some of which may have occured by chance. Following from this, it may be more advisable to do further work in this area using Traffic Districts instead of Traffic Zones.

2. It is interesting to note that a meaningful pattern of the distribution of the residuals is not obtained although there seems to be a core-periphery bias in the distribution of the residuals for the industrial zones. This seems to indicate that no further spatial pattern is evident from the variables used in this study. Perhaps they are not appropriate for emphasizing the spatial pattern of work trip distribution in the city. More investigation in this area is suggested in order to obtain more meaningful conclusions concerning this.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this thesis was to investigate the relationship between residential location and place of work in Edmonton. The major objectives of the study were to identify and attempt an explanation of spatial pattern of work trip distribution to major employment centers in the city and their respective work trip catchment areas and work trip lengths. Multiple Linear regression was used to identify the important factors underlying the observed pattern of work trip distribution. The investigation was carried out using the 1971 Origin-Destination data and Land Use data for the 234 Traffic Zones in the city obtained from the City of Edmonton, Transportation Planning Branch.

8.1 FINDINGS AND CONCLUSIONS OF THE STUDY

Despite the overwhelming complexities underlying human behaviour and the complex nature of urban spatial interaction, some interesting findings related to people's adaptation to city space and the resulting patterns of journey to work in Edmonton have been revealed. Although the distribution of employment centers is concentrated in space, while the intensity of work trip generation is fairly dispersed with varying densities within the city, there is a general trend underlying the observed pattern of work trip distribution in the city.

The Central Business District receives the highest proportion of work trips generated by most Traffic Zones in the city since the demand for work trips is highest in the district. Consequently the work trip catchment area of the Central Business District approximates the residential location pattern for the city. This observation is comparable with situa-

tions existing in other urban areas. The large number and variety of workers demanded in the Central Business District for its governmental, institutional, commercial and other miscellaneous functions can only be satisfied from the entire urban area. The results of the analysis indicate that the intensity of work trip generation in the city and the intensity of demand for work trips in the district are the major explanatory variables related to work tripmaking to the district.

Measures of spatial separation in the form of distance and travel time are significantly related to work tripmaking to the Central Business District but do not increase the amount of variation explained. This suggests that the generation pattern takes the measures of spatial separation into account indirectly. Since the Central Business District is well served by the transit system, distance is not a major deterrent to work tripmaking to the district since employees in the district find that they can get to work in time and without incurring undue travel costs, irrespective of where they live in the city. Therefore, other factors that may influence the residential location pattern of distribution of employees in this district include housing preferences, neighbourhood considerations and other economic and sociological factors. However, the influence of the generation intensity is so strong that the introduction of variables related to accessibility, land use density and socio-economic factors fail to enhance explanation. Therefore one major conclusion of this is that the distribution of work trips to the Central Business District is controlled largely by the work trip generation intensity of most zones.

The work trip attracting ability of other employment centers in the city is secondary to that of the Central Business District because their work trip demands are not satisfied until after the demand in the

Central Business District has been satisfied. There is also a strong relationship between a Traffic zone's proximity to any of the industrial zones and more workers living in that zone getting employed in this nearest employment center. This indicates the tendency for workers to live near their place of work. Similar trend is observed in the University of Alberta. Consequently, the work trip catchment areas of these employment centers are found in their respective vicinity or in areas immediately around them. Attempts to develop models for the University of Alberta were unsuccessful.

Although the distribution of commuters to the peripheral industrial zones demonstrates a more tightly clustered pattern around each destination, a strong distance-decay effect is evident. The results of the analysis show that the model which incorporates the generation and attraction factors as well as a measure of spatial separation represents more fully the observed pattern of work trip distribution to the industrial zones. This situation is so stable that one model which incorporates these variables has been developed, which performs well in each of the industrial zones.

The introduction of variables related to accessibility, residential land use density and measures of socio-economic characteristics of the Traffic Zones improve models for the industrial zones, slightly. This indicates that these variables incorporate some factors related to work trips to the industrial zones which the generation, attraction, and measures spatial separation fail capture. It is interesting to note that the proportion of low density residential land is positively related to work trips to the industrial zones but inversely related to work trip-making to the Central Business District.

The introduction of socio-economic variables in the form of parking cost at destination and automobile ownership ratio at origin failed to improve the models in all the employment centers. There exists some data on other socio-economic characteristics of the zones which could not be used because these were collected on the basis of census tracts which are not coincident with Traffic zones on Traffic Districts as used in this study. It is hoped that when geocoding of variables is fully implemented, this problem will be eliminated since it allows for any level of aggregation and for the use of comparable data bases.

The logarithmic transformation of the variables improved the level of explanation in all the employment centers except the North west industrial zones. When used for prediction, these models improve the linear fit in the industrial zones but not in the Central Business District. Although they improved prediction for work trips when aggregated according to Traffic Districts in the industrial zones, they grossly under-predict total trips made to these destinations. This indicates that although the relationship between work tripmaking and the variables used in the analysis may not be a simple linear relationship, it is not clear whether the use of logarithm transformation of the variables is the best functional form.

The testing of the models indicates that the models give a better linear fit when the results are aggregated according to Traffic Districts. This shows that these models seem to perform better on a larger scale than on smaller scale of Traffic zones. However, when the residuals are plotted on a map they do not indicate any easily recognizable patter in their variation. There is no readily available explanation for this since more investigation is needed in this area.

8.2 RECOMMENDATIONS FOR FURTHER RESEARCH

As a result of the conclusions obtained from this investigation, the following points are offered as recommendations for further studies.

1. Due to the importance of generation (O_i) in all the models, especially in the Central Business District, an alternative approach to the problem of predicting residential location may be obtained by studying the activity pattern of the workers residing in a zone. This could be done by first identifying various recent mover groups, classifying them according to particular points of origin and destination and then studying the activity patterns of these recent mover groups. This would enable the hypothesis that different mover groups make different residential choice patterns, not necessarily controlled by their employment locations, to be tested.
2. The measures of spatial separation seemed to have been indirectly taken into consideration by the generation factor, when work trips to the Central Business District are considered. Therefore, a study of housing preferences may reveal more factors related to work tripmaking to the district. Studies in housing preferences in North America indicate the tendency for majority of urban dwellers to move into single family houses in the metropolitan outer rings, regardless of their places of employment. Stegman (1969) has shown that neighbourhood considerations are more important to residential consideration than accessibility to the place of work. In fact, it has been shown that large numbers of suburban families do not have to trade off accessibility for location rent since they can have both. This is borne out by the strong distance-decay factor in work trips to the Edmonton industrial zones.

In Edmonton, the effect of owner occupied housing may be an important factor influencing residential location. Therefore, a survey of housing preferences is suggested since it may reveal more about factors such as location, neighbourhood considerations, price, space and time of move which explain why families decide on particular types of housing in the city.

3. Since attempts to develop models for the University of Alberta were unsuccessful, it is suggested that further investigation using a different approach and possibly other variables should be carried out in order to determine factors underlying the pattern of work trip and student trip attraction to this important destination in the city.

4. Differences have been observed between the spatial pattern of work trip attraction of the Central Business District on the one hand as well as in the land use density variables related to them and the industrial zones on the other. It is suggested that the relative importance of the different modes of transportation, differences in income, sex and age composition of the labour force for the Central Business District and for the industrial zones should be further investigated in order to find out if they also differ significantly with respect to these characteristics.

5. Since the log transformations of the variables improved the variation explained in the analysis and also improved the results obtained when the models are used for prediction, other forms of transformation should be investigated. There may not be a simple linear relationship between work tripmaking and the variables used in this study.

6. Since the use of dummy variables indicating the location of each

employment center failed to enhance explanation, it is recommended that the approach should further be investigated using the quality of the location. This might be done by using the house sale value of a plot of land in each zone or any other appropriate measure.

7. Since the results obtained from the testing of the models indicate that the models perform better on the aggregated scale using Traffic Districts than on the smaller scale using Traffic Zones, it is recommended that further work in this area should be done using Traffic Districts.

8. Since a meaningful pattern of the distribution of residuals is not obtained, it is suggested that further investigation should be carried out in order to find out the possible reasons for this.

9. A similar study using the 1976 origin-destination data should be conducted in order to assess the stability of the models obtained in this study over a period of time. There exists data on journey to work in Edmonton collected in the Federal Census of 1971. Although this data was obtained on a limited basis, a similar study using this data could be compared with the present study. Since this data exists for other metropolitan areas in Canada, the results from it can be compared for the different urban areas in Canada and with the interesting results of this study in order to assess whether the results obtained here are peculiar to Edmonton, or are representative of the behaviour of urban dwellers in Canadian cities in general.

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APPENDIX I (A)

LAND USE DATA

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FORMAT OF TPSR:LANDUSE.1971

WORD# TYPE    DESCRIPTION

  1   INTEGER TRAFFIC ZONE NUMBER
  2   REAL    TOTAL CLASSIFIED LAND IN ACRES IN THIS ZONE
  3   REAL    LOW RESIDENTIAL LAND IN ACRES IN THIS ZONE
  4   REAL    MEDIUM RESIDENTIAL LAND IN ACRES IN THIS ZONE
  5   REAL    HIGH RESIDENTIAL LAND IN ACRES IN THIS ZONE
  6   REAL    SHOPPING CENTRE LAND IN ACRES IN THIS ZONE
  7   REAL    STRIP DEVELOPMENT LAND IN ACRES IN THIS ZONE
  8   REAL    CENTRAL AREA OFFICE LAND IN ACRES IN THIS ZONE
  9   REAL    HIGHWAY STRIP DEVELOPMENT LAND IN ACRES IN THIS ZONE
 10   REAL    GOVERNMENT-INSTITUTIONAL LAND IN ACRES IN THIS ZONE
 11   REAL    UNIVERSITY-COLLEGE LAND IN ACRES IN THIS ZONE
 12   REAL    TOTAL INDUSTRIAL LAND IN ACRES IN THIS ZONE
 13   REAL    RECREATIONAL-AGRICULTURAL LAND IN ACRES IN THIS ZONE
 14   REAL    OTHER CLASSIFIED LAND LAND IN ACRES IN THIS ZONE
 15   REAL    VACANT URBAN LAND LAND IN ACRES IN THIS ZONE

THIS COULD BE READ IN FORTRAN AS FOLLOWS:

      INTEGER ZONE
      REAL ACRES(14)
      ...
      ...
      READ(1,100)ZONE,ACRES
100   FORMAT(15A4)
      ...
      ...
      END


THERE ARE 234 RECORDS CORRESPONDING TO THE SAME 234 ZONES
REFERENCED IN PREVIOUS DATA.
```

AGGREGATION OF ZONING CLASSIFICATIONS

1.	LOW DENSITY RESIDENTIAL	R1, RC1, R2
2.	MEDIUM DENSITY RESIDENTIAL	R2A, R3, R4, P3 SOME R3A, SOME R5
3.	HIGH DENSITY RESIDENTIAL	HIGH-RISE WITH ELAVATOR R6, R7 SOME R3A, SOME R5
4.	COMMERCIAL SHOPPING CENTRE	C2
5.	COMMERCIAL STRIP DEVELOPMENT	C1, C2A, C3, SOME C5
6.	COMMERCIAL HIGHWAY STRIP DEVELOPMENT	C7, C8, C9
7.	CENTRAL AREA OFFICE/COMMERCIAL	C4, C6, SOME C5, CC
8.	GOVERNMENT-INSITITUTIONAL	P1, P2, MA
9.	UNIVERSITY-COLLEGE	HIGHER EDUCATION FACILITIES
10.	TOTAL INDUSTRIAL	M1, M2, M3
11.	RECREATIONAL-AGRICULTURAL	A, AP, AG
12.	VACANT URBAN LAND	LAND WHICH HAS BEEN ZONED FOR DEVELOPMENT BUT AS YET IS UNDEVELOPED
13.	OTHER CLASSIFIED LAND	ALL OTHER LAND EXCEPT ROADWAY AND UTILITY RIGHTS-OF-WAY
14.	TOTAL CLASSIFIED LAND	TOTAL OF ALL CLASSIFIED LAND IN EACH ZONE

THE CITY OF EDMONTON — PLANNING DEPARTMENT

GENERAL SUMMARY OF LAND USE DISTRICTS

The following descriptions provide general information on the various zones or classifications which the city applies to guide and regulate the use of land. These condensed descriptions are for general information only and the Zoning Bylaw (Bylaw 2135) and the Land Use Classification Guide (map and schedule of permitted uses and regulations) must be referred to for specific inquiries.

A — METROPOLITAN RECREATION DISTRICT — This zone is generally applied to land which is used or proposed to be used as public parkland. The river valley and ravine system is included as is certain landscaped buffer areas flanking major arterial roads. Recreational and municipal uses are common types of development located in such areas.

AP — PUBLIC PARKS DISTRICT — This zone is generally applied to neighbourhood parkland areas. Land is often located in such a manner that use is mainly by local neighbourhood residents rather than City wide. Community leagues, playgrounds, and other municipal uses are common types of development.

AS, AR, RRA, RRB, RRC - RESIDENTIAL DISTRICT — These zones are all basically single family dwelling areas which are more restrictive in terms of site area, and building location than the normal single family zone. Small acreages and country estates which are located within the City boundaries are included as well as ravine and view lots.

R-1 — RESIDENTIAL DISTRICT — Essentially a single family zone, but which also allows other uses, some of which may be permitted subject to the right of appeal to the Development Appeal Board.

RC-1 — RESIDENTIAL CONVERSION DISTRICT — Essentially a low density district applied to many older areas of the City. Allows a mixture of one and two family dwellings depending on site area and under certain circumstances four suite apartment buildings may be permitted, but subject to the right of appeal to the Development Appeal Board.

R-2 — RESIDENTIAL DISTRICT — Two family dwelling zone, usually applied to newer areas of the City. Semi-detached dwellings are common uses in these zones.

R-2A — RESIDENTIAL DISTRICT — Terraced dwelling (row housing) zone usually applied in newer areas of the City.

R-3 and R-4 - RESIDENTIAL AND GENERAL RESIDENTIAL DISTRICT - Usually applied to the newer residential areas and to older districts which are not centrally located in the City. Walk-up apartment buildings are common uses.

R-3A — SUBURBAN MEDIUM DENSITY RESIDENTIAL DISTRICT — Medium density apartment district applied to areas which are adjacent to major suburban shopping centres or town centres.

R-5 — MEDIUM DENSITY RESIDENTIAL DISTRICT — Medium density apartment district applied to areas which are adjacent to the central area of the City and in some suburban locations adjacent to major regional shopping or institutional centres. Walk-up apartment buildings and medium rise apartment buildings are common uses.

R-6 — HIGH DENSITY RESIDENTIAL DISTRICT — High density high rise apartment district usually located within or adjacent to the central area of the City. Limited commercial or office uses are common to such areas.

R-7 — RESIDENTIAL AND SPECIAL PURPOSE OFFICE DISTRICT — This district permits a mixture of residential and office uses and buildings are often multi-storied or high rise structures.

P-1 — PUBLIC SERVICE DISTRICT — Public service district allowing municipal services such as schools, utility buildings and other service installations.

P-2 — PRIVATE SERVICE DISTRICT — Private service district allowing private institutional uses such as hospitals, churches, homes for the aged, educational uses, etc.

P-3 — RESIDENTIAL DISTRICT — Residential zone providing non-profit residential accommodation of the public housing type.

C-1 — COMMERCIAL DISTRICT — Commercial zone usually applied to local neighbourhood shopping areas and service station sites.

C-2 — COMMERCIAL DISTRICT — Commercial zone applied to shopping centres in suburban locations and to other commercial areas which provide a wide range of services to a part of the City.

C-2A — COMMERCIAL DISTRICT — Commercial zone applied to older established strip commercial areas usually located along major arteries.

C-3 — GENERAL COMMERCIAL DISTRICT — Commercial zone applied to older major commercial areas such as Whyte Avenue, 118th Avenue in the Beverly area and Jasper Avenue west of 109th Street. These areas provide major shopping facilities and in some cases were former centres of towns which have been amalgamated with the City.

C-4 – CENTRAL RETAIL AND OFFICE DISTRICT – Central retail and office district in downtown Edmonton.

C-5 – MOTEL AND SPECIAL PURPOSE OFFICE DISTRICT – as implied by the district name.

C-6 – GOVERNMENT CENTRE AND OFFICE DISTRICT – as implied by the district name.

C-7 – (RESTRICTED) TOURIST COMMERCIAL DISTRICT – Commercial district applied only to motel uses and uses accessory to motel developments.

C-8 – HIGHWAY COMMERCIAL DISTRICT – Highway commercial district applied to major entrances to the City to encourage commercial uses orientated to the travelling public.

C-9 – MAJOR ARTERIAL COMMERCIAL DISTRICT – Commercial district applied to major arterial roads leading into the City where a wide range of commercial and semi-industrial uses are situated.

M.A. – MUNICIPAL AIRPORT DISTRICT – Zoning category applying only to the Industrial Airport property.

CM – WHOLESALE DISTRIBUTION DISTRICT – Commercial and industrial, wholesale and warehousing district located in the central portion of the City adjacent to the central business district.

CU – UNIVERSITY COMMERCIAL DISTRICT – Commercial, office and apartment district adjacent to and serving the University area.

CC – CIVIC CENTRE DISTRICT – The Civic and Community Centre of the City containing administrative buildings and related compatible uses, including hotel and meeting facilities.

M-1, M-2 and M-3 – INDUSTRIAL DISTRICT – Industrial districts which vary according to land use and performance standards, A common description would be light, medium and heavy industrial zones.

AG-MR1 and AG-MR2 – INDUSTRIAL RESERVE DISTRICT – Industrial reserve districts applied to areas which are to be held for future expansion of industry. Usually located on the fringe of the City and used for agricultural purposes. Premature development within these areas is discouraged so that city expansion can occur on an orderly and economic basis.

AG – AGRICULTURAL DISTRICT – The general purpose of this district is to conserve the natural resources of such areas for purposes of primary production and to prevent the wastage of agricultural land on the fringe of the city by premature or scattered subdivision or development.

AG-UR – AGRICULTURAL URBAN RESERVE DISTRICT – This district category is applied to land which is being held for city expansion purposes and where it is desirable to control development to prevent the establishment of any use or building which would prejudice the orderly development of the area.

AG-U – AGRICULTURAL GENERAL URBAN DISTRICT – The general purpose of this district is to control the orderly development of the city through the adoption by Council of a plan of subdivision and permitted uses where detailed zoning and more specific categories have not yet been applied.

Date: January 1972

APPENDIX I (B)

TRIP INTERCHANGE DATA

The City of Edmonton

Engineering and Transportation Department

Transportation Planning Branch

Office of the City Engineer
Edmonton, Alberta
Canada
T5J 2R7

April 28th, 1975.
File No.: 19066 XR: 500.09.6

Professor John Hodgson,
Department of Geography,
University of Alberta,
Edmonton, Alberta.
T6G 2H4

RE: 1971 Origin-Destination Statistics

Dear Sir:

We have now copied the tape file containing data for the 234 traffic zones to your tape number 0579. I have enclosed a description of the record layout together with the format and blocking parameters.

If you have any questions (or suggestions) please do not hesitate to contact me at 425-2485.

Yours truly,

T. O. Clement, Research Engineer,
Studies and Research Section,
TRANSPORTATION PLANNING BRANCH.

TOC:mba

TIF.ALL.V01.F234

Record Format FB(16848,72) 234 Blocks

Layout:

Word Number	Description of Variable and Units
1	Origin Zone Number
2	Destination Zone Number
3	Transit Choice Trips from Origin to Destination
4	Transit Captive Trips
5	Auto-Driver Choice Trips
6	Auto-Driver Captive Trips
7	Fraction by Transit of Choice Trips (3/(3+5))
8	Distance in Tenths of a Mile
9	Auto In-Vehicle Time in Tenths of a Minute
10	Transit In-Vehicle Time in Minutes
11	Number of Transfers
12	Wait Time=Half the Headway of First Bus
13	Transfer Time=½ Sum of Headways of Other Buses
14	Excess Transit Distance at Origin in Metres
15	Car Ownership at Origin in Cars per Person
16	Excess Transit Distance at Destination in Metres
17	Excess Auto Distance at Destination in $\frac{1}{100}$ Blocks
18	Parking Cost at Destination in Cents per Month

File is sorted by Origin Zone Primary
Destination Zone Secondary

Each block contains all records relevant to one origin zone.

All variables are stored as floating point single precision binary so as to avoid the expense of converting from character (decimal) format to binary each time the file is read.

The file can therefore be read in one of two ways in fortran.

1. With system blocking on (default)

```
         Real A (18)
         Do 10000 I = 1,54756
         Read (1,100) A
100      Format (18A4)
           .
           .
           .
           .
           .
10000    Continue
           .
           .
```

2. With system blocking off (blk=off)

```
         Real A (18,234)
         Do 10000 I = 1,234
         Read (1,100) A
100      Format (18(234A4))
           .
           .
           .
           .
           .
10000    Continue
           .
           .
```

The second method is considerably more efficient and hence quicker and cheaper.

APPENDIX II

TOTAL POPULATION, AREA, EMPLOYMENT AND EMPLOYEES BY TRAFFIC ZONE

TOTAL POPULATION, TOTAL CLASSIFIED LAND, EMPLOYEES AND

EMPLOYMENT BY TRAFFIC ZONES

Traffic Zone	Total Population	Area of Zone (Acres)	Employees		Employment	
			Total	A.M. Peak Hour	Total	A.M. Peak Hour
11	122	32.32	36	10	1773	1208
12	14	27.62	12	0	3679	1627
13	550	39.78	208	31	3491	1852
14	200	35.21	62	7	5571	2579
21	613	76.22	360	60	6565	4401
22	3382	120.45	1781	380	792	380
31	1216	43.41	375	28	6767	3569
32	970	133.40	214	50	7867	4704
41	0	1.90	0	0	10	5
42	0	44.71	0	0	74	33
44	0	51.67	0	0	342	188
45	3947	162.28	1532	547	353	181
46	334	10.44	151	55	221	62
51	0	121.90	0	0	728	437
52	0	26.97	0	0	862	1370
53	3337	190.02	1200	399	1372	501
54	0	10.21	0	0	270	107
55	2	58.38	0	0	792	575
56	1801	168.22	663	285	584	246
61	4	38.64	1	1	835	617
62	6759	183.21	3296	1399	743	432
63	6	59.39	3	2	201	134
64	52	36.12	21	2	1023	649
71	4299	169.54	2383	803	3778	1404
72	2772	77.73	771	169	1524	824
73	157	38.93	35	6	890	489
81	0	31.84	0	0	258	172
82	0	33.92	0	0	363	187
83	27	40.54	6	1	144	69

Traffic Zone	Total Population	Area of Zone (Acres)	Employees Total	Employees A.M. Peak Hour	Employment Total	Employment A.M. Peak Hour
84	4571	159.34	1484	572	342	163
85	4342	174.28	1611	605	440	193
86	3456	148.21	1310	454	336	142
87	17	94.18	5	2	1038	373
91	5484	153.26	1695	610	504	233
92	4429	132.18	1377	495	627	294
93	656	37.43	220	52	141	68
101	3664	90.67	876	254	485	256
102	304	43.36	81	15	217	95
103	413	35.29	181	76	905	446
104	2271	70.54	1183	517	118	35
105	2915	94.65	886	260	374	180
106	1249	115.61	379	132	84	39
111	524	171.58	175	83	137	74
112	3576	167.65	1225	488	190	85
113	1620	82.67	628	252	88	24
114	232	76.73	72	38	652	337
115	954	58.70	309	142	47	18
116	1137	236.91	376	158	62	33
121	134	221.85	47	17	229	123
122	677	98.93	203	63	1091	436
123	11	73.26	2	1	939	277
124	903	71.40	267	93	26	10
125	693	23.16	206	57	87	22
126	5401	214.29	1736	622	208	63
131	973	149.36	284	95	40	18
132	4815	182.87	1524	563	380	105
133	12	144.83	5	3	11	4
134	3456	196.23	1161	424	171	63
135	1487	103.20	418	153	61	31
137	2573	142.00	826	333	142	74
191	2959	287.09	975	426	71	24
192	4757	210.46	1443	565	85	27

Traffic Zone	Total Population	Area of Zone (Acres)	Employees Total	Employees A.M. Peak Hour	Employment Total	Employment A.M. Peak Hour
201	4954	227.62	1480	512	195	50
202	192	57.51	61	9	14	4
203	74	22.08	25	7	79	32
211	5863	221.19	1816	724	111	34
212	5672	265.41	1812	693	443	142
221	5204	261.87	1749	701	256	125
222	3688	192.50	1175	498	76	28
223	30	40.74	12	5	53	34
261	1876	244.11	603	281	92	38
262	2582	216.78	885	351	153	64
271	0	28.02	0	0	15	5
272	4937	205.91	1682	656	273	134
273	2404	114.59	889	328	222	107
274	3834	144.71	1275	489	254	87
281	4522	231.71	1440	533	1151	349
282	1072	117.16	402	156	72	28
283	2715	110.19	983	371	326	103
284	0	64.94	0	0	1451	529
321	2812	133.40	948	426	168	50
322	2811	91.88	888	371	108	40
323	3181	134.11	1051	389	185	74
324	2153	91.11	667	271	113	33
331	284	161.40	81	39	115	65
332	5292	201.17	1619	703	180	67
333	2985	123.50	920	396	142	66
363	18	265.91	6	4	628	396
393	43	304.93	12	3	137	67
394	0	144.29	0	0	675	445
395	0	98.22	0	0	546	366
396	0	44.28	0	0	61	30
401	0	67.64	0	0	488	265
402	9	142.38	7	2	151	92
403	0	229.73	0	0	1919	1301

Traffic Zone	Total Population	Area of Zone (Acres)	Employees Total	Employees A.M. Peak Hour	Employment Total	Employment A.M. Peak Hour
404	37	141.55	7	4	330	196
405	0	228.62	0	0	1861	1225
406	356	75.65	144	49	549	304
411	3534	161.59	1171	543	196	88
412	2888	112.52	1074	488	481	234
413	0	99.38	0	0	217	49
414	0	41.39	0	0	474	84
415	1327	28.08	638	271	32	19
416	779	40.11	302	132	154	64
421	152	55.56	40	18	311	162
422	254	29.55	83	26	195	130
423	3987	157.73	1402	513	158	76
424	2088	134.35	679	281	591	244
431	1343	66.17	541	192	529	135
432	3903	142.68	1839	774	192	84
433	1935	90.98	682	353	181	93
434	2676	97.36	1076	412	577	288
441	592	30.84	205	79	20	8
442	4487	142.68	2262	1012	1793	946
443	802	126.41	357	137	411	178
444	2733	39.94	1482	728	693	286
451	1838	26.51	1043	410	291	173
452	7	29.15	4	1	250	150
453	2564	35.59	1386	563	877	432
454	429	16.58	232	56	1050	365
455	2640	139.65	1135	428	132	50
461	2424	119.66	792	365	268	105
462	2826	135.30	1071	527	186	58
463	3002	157.36	1061	461	226	104
464	3215	191.45	1283	578	222	79
465	1003	126.87	309	101	46	27
471	3613	138.38	1133	509	120	46
472	2607	110.63	848	313	97	28

Traffic Zone	Total Population	Area of Zone (Acres)	Employees		Employment	
			Total	A.M. Peak Hour	Total	A.M. Peak Hour
473	1398	77.78	437	213	33	15
474	2699	124.12	901	364	109	44
475	2664	120.70	856	341	103	49
476	0	21.66	0	0	33	6
477	142	69.13	47	16	334	135
478	884	65.63	260	100	278	102
479	1640	58.55	613	215	563	167
491	1954	142.61	760	289	178	70
492	2422	114.54	785	282	61	20
493	2936	117.83	982	368	55	19
494	3883	214.45	1314	624	897	288
495	4031	158.24	1205	578	215	64
496	4511	189.92	1402	568	230	74
497	0	30.33	0	0	225	42
501	3686	246.43	1256	640	153	50
502	1124	174.20	331	218	30	6
503	1870	80.72	613	310	26	10
504	1843	335.30	501	247	35	16
505	3421	194.77	956	579	99	26
506	42	177.94	12	7	8	1
511	5743	252.73	1758	738	610	162
512	1958	101.31	612	329	65	27
513	1889	167.80	587	345	53	17
514	2172	142.46	641	390	59	20
515	414	46.17	107	72	4	0
592	97	206.03	16	6	10	2
593	1315	93.23	330	204	35	16
595	822	111.16	199	123	19	11
601	3	273.08	1	0	2	2
602	1732	139.46	509	192	112	43
603	20	131.11	10	2	7507	5977
604	152	121.88	2	0	669	274
605	3256	98.55	936	209	648	201

Traffic Zone	Total Population	Area of Zone (Acres)	Employees		Employment	
			Total	A.M. Peak Hour	Total	A.M. Peak Hour
611	3402	248.60	1142	550	213	116
612	1553	379.26	404	307	67	22
613	260	90.65	51	24	128	68
622	1862	218.73	582	325	85	29
632	3058	129.44	1011	548	781	129
633	999	41.80	95	167	5	1
634	2677	108.91	788	452	212	68
641	3446	658.96	838	571	125	56
651	4536	207.42	1634	872	289	123
652	1711	202.35	567	265	112	49
653	511	147.20	81	41	11	5
654	5022	207.77	1426	814	94	36
681	3022	163.94	1181	518	191	59
682	2703	107.61	903	364	311	138
683	0	82.12	0	0	15	4
684	2015	129.85	604	280	89	26
691	3905	158.33	1385	407	132	46
692	4753	185.15	1927	744	707	343
693	3025	144.30	1107	586	120	47
694	2362	102.47	878	347	77	16
695	1517	71.61	556	193	251	131
701	50	120.84	16	5	148	93
702	4397	101.83	2101	714	1511	525
703	3168	93.68	1426	644	408	163
704	3298	111.18	1304	633	83	33
711	59	63.24	26	7	620	356
712	623	58.39	215	79	592	347
713	0	95.04	0	0	268	174
714	19	133.62	9	3	607	294
721	338	56.44	112	37	70	30
722	2442	188.23	755	309	167	57
723	2663	95.69	1008	472	223	69

Traffic Zone	Total Population	Area of Zone (Acres)	Employees Total	Employees A.M. Peak Hour	Employment Total	Employment A.M. Peak Hour
724	0	30.65	0	0	322	74
725	2375	105.45	911	416	329	78
731	754	169.29	244	95	123	33
732	3373	134.70	1247	559	149	45
733	5241	307.73	1676	754	185	61
741	4	230.12	3	3	108	70
742	53	14.76	15	7	15	5
743	2824	111.94	1041	468	130	59
744	2020	99.06	697	318	137	29
745	1682	66.23	528	247	141	34
746	1298	88.66	488	172	78	25
747	1779	55.58	741	289	119	33
748	0	36.67	0	0	138	16
749	3	17.64	1	1	22	11
751	3281	165.78	1103	561	142	58
753	1971	97.77	684	353	21	7
754	3312	150.21	1095	576	267	123
755	4133	177.63	1220	550	97	33
781	3290	129.76	1071	513	203	60
782	6197	274.60	1889	886	288	101
783	5524	236.01	1879	815	599	269
793	0	751.77	0	0	116	44
821	2324	76.92	867	380	65	25
822	2353	124.91	832	333	551	238
823	1587	68.85	616	254	189	71
824	3367	131.61	1077	524	155	63
831	473	43.48	170	74	7	2
832	4280	164.71	1518	650	209	78
833	4652	275.72	1555	782	422	193
841	27	90.88	7	0	956	637
842	3	196.50	2	0	1112	809
843	44	204.29	9	6	816	550
844	2	81.46	2	0	208	116

Traffic Zone	Total Population	Area of Zone (Acres)	Employees		Employment	
			Total	A.M. Peak Hour	Total	A.M. Peak Hour
845	0	253.47	0	0	129	80
851	40	168.20	4	1	376	273
852	17	366.99	6	3	650	459
861	11	85.68	2	1	102	56
862	12	51.59	7	1	323	220
863	16	991.24	5	2	628	433
891	5	105.92	2	0	62	24
892	49	529.75	5	4	343	211

APPENDIX III

TOTAL EMPLOYEES AND DISTRIBUTION

TO MAJOR EMPLOYMENT CENTERS

TOTAL EMPLOYEES AND DISTRIBUTION TO MAJOR EMPLOYMENT CENTERS BY TRAFFIC ZONES

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
11	10	3	4	1		
12	0					
13	31	6	7		1	1
14	7	2	2	1		
21	60	7	7	3	9	
22	380	88	97	22	13	1
31	28	6	2	4	2	
32	50	23	4	2	2	
41	0					
42	0					
44	0					
45	547	243	39	21	15	24
46	55	28	5	2		2
51	0					
52	0					
53	399	153	32	33	13	7
54	0					
55	0					
56	285	97	23	18	12	6
61	1					
62	1399	527	105	126	43	27
63	2	1		1		
64	2				1	
71	803	370	46	43	18	13
72	169	57	4	12	7	6
73	6	3		1		
81	0					
82	0					
83	1	1				

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
84	572	199	22	36	19	27
85	605	166	22	50	18	45
86	454	140	14	25	19	34
87	2	1				1
91	610	188	33	44	22	10
92	495	156	20	21	23	24
93	52	14	3	2	2	1
101	254	79	14	16	11	17
102	15	5	2		1	1
103	76	28	12	3	5	
104	517	253	30	22	21	9
105	260	80	37	13	18	10
106	132	50	9	6	3	3
111	83	12	2	3	10	3
112	488	170	26	22	26	34
113	252	92	14	11	9	14
114	38	18	10	2		
115	142	39	13	5	9	8
116	158	83	4	4	4	5
121	17	2			1	2
122	63	19	5	8	1	3
123	1					
124	93	25	8	4	1	8
125	57	10	2	5	3	5
126	622	176	35	38	24	46
131	95	21	1	2	10	10
132	563	176	28	38	36	43
133	3			3		
134	424	138	28	20	16	25
135	153	57	15	5	8	5
137	333	114	15	17	22	19
191	426	141	21	52	16	20
192	565	150	17	50	32	47

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
201	512	164	12	55	10	56
202	9	4		2		
203	7	1	1	1		1
211	724	205	31	49	17	45
212	693	174	20	63	26	48
221	701	184	30	77	27	22
222	498	130	36	38	20	17
223	5	1	1			
261	281	87	17	26	2	11
262	351	100	17	35	5	9
271	0					
272	656	198	34	62	22	26
273	328	130	8	21	9	8
274	489	177	11	46	16	26
281	533	192	12	47	17	16
282	156	40	3	10	8	3
283	371	132	26	30	6	9
284	0					
321	426	129	14	57	19	8
322	371	109	15	31	6	7
323	389	118	24	48	15	7
324	271	71	11	33	13	4
331	39	6	3	6		1
332	703	210	41	81	25	7
333	396	125	15	62	9	4
363	4	1	1			1
393	3					
394	0					
395	0					
396	0					
401	0					
402	2	2				
403	0					

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
404	4	2		2		
405	0					
406	49	8	1	8	1	1
411	543	178	40	72	23	9
412	488	142	47	69	11	4
413	0					
414	0					
415	271	76	47	40	9	2
416	132	30	19	22	5	2
421	18	3		3		
422	26	6		4	2	
423	513	174	31	63	7	10
424	281	62	10	46	15	6
431	192	61	12	21	6	5
432	774	246	55	89	26	4
433	353	104	42	41	9	5
434	412	155	31	47	10	1
441	79	29	15	6	1	
442	1012	411	87	72	30	7
443	137	70	11	9	2	1
444	728	340	72	36	9	8
451	410	156	59	25	17	3
452	1					
453	563	249	66	25	22	3
454	56	24	9	4	1	1
455	428	192	51	23	8	5
461	365	113	19	63	22	5
462	527	194	36	52	19	7
463	461	161	30	56	20	5
464	578	228	55	46	15	3
465	101	39	14	10	2	
471	509	137	24	93	20	5
472	313	65	22	65	28	5

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
473	213	57	7	37	10	1
474	364	91	14	76	28	7
475	341	83	15	59	20	8
476	0					
477	16	6		1		2
478	100	18	10	17	5	2
479	215	39	15	35	9	2
491	289	95	17	42	13	2
492	282	84	13	54	11	2
493	368	88	30	72	18	3
494	624	189	62	95	21	3
495	578	191	45	89	29	8
496	568	146	52	83	31	5
497	0					
501	640	219	63	69	13	6
502	218	68	43	17	5	1
503	310	121	25	35	9	7
504	247	101	18	23	4	
505	579	203	73	45	12	4
506	7	3	2	1		
511	738	217	31	109	29	4
512	329	97	45	30	7	2
513	345	113	37	35	19	2
514	390	157	18	47	8	1
515	72	28	6	6		1
592	6	3				
593	204	70	31	12	14	
595	123	48	16	2	11	
601	0					
602	192	72	32	2	15	
603	2	1	1			
604	0					
605	209	75	23	1	9	2

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
611	550	137	159	10	38	4
612	307	77	98	5	28	
613	24	4	10		4	
622	325	76	77	22	38	4
632	548	173	94	17	70	2
633	167	8	137			1
634	452	154	68	15	53	3
641	571	178	110	22	55	1
651	872	192	170	23	121	2
652	265	63	49	7	37	
653	44	17	8	4	3	1
654	814	255	121	24	81	7
681	518	148	85	13	84	4
682	364	68	58	25	77	
683	0					
684	280	57	45	8	61	
691	407	136	89	12	24	1
692	744	194	178	23	70	7
693	586	163	158	13	59	4
694	347	104	58	16	43	2
695	193	34	20	11	36	1
701	5	1			1	
702	714	227	150	23	64	5
703	644	210	148	19	77	4
704	633	154	152	22	67	5
711	7	1	2			
712	79	27	11	4	9	
713	0					
714	3					
721	37	12	4	2	4	
722	309	89	39	8	41	
723	472	139	57	20	70	5
724	0					

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
725	416	122	47	14	61	5
731	95	28	13		13	4
732	559	228	47	21	65	6
733	754	245	77	24	70	5
741	3	2	1			
742	7	2				1
743	468	195	30	12	29	7
744	318	93	22	12	37	2
745	247	88	17	14	33	3
746	172	63	8	5	20	4
747	289	99	22	3	36	5
748	0					
749	1					1
751	561	218	60	14	43	15
753	353	134	16	8	38	8
754	576	196	75	28	51	10
755	550	189	33	21	86	3
781	513	194	42	17	54	6
782	886	301	76	24	111	12
783	815	208	41	31	167	7
793	0					
821	380	96	72	11	64	4
822	333	91	38	14	54	1
823	254	64	32	11	55	
824	524	137	63	22	106	6
831	74	17	15	5	6	
832	650	167	85	20	88	9
833	782	216	92	26	147	7
841	0					
842	0					
843	6			3	3	
844	0					
845	0					

Traffic Zone	Total A.M. Peak Hour Employees	Trips to CBD	Trips to U of A	Trips to N.W. Industrial Zone	Trips to S.E. Industrial Zone	Trips to N.E. Industrial Zone
851	1	1				
852	3	1			2	
861	1			1		
862	1					
863	2	1		1		
891	0					
892	4	1	1			

APPENDIX IV

DESCRIPTIVE STATISTICS ASSOCIATED WITH MULTIPLE REGRESSION

DESCRIPTIVE STATISTICS ASSOCIATED WITH MULTIPLE REGRESSION

1. Form of the Equation: - The multiple linear regression equation has the following general form,

$$Y = a + b_1 X_1 + b_2 X_2 + - - - - + b_n X_n + e$$

where,

Y = The dependent or estimated variable.

$X_1, X_2, - - - - X_n$ = The independent or explanatory variables.

a = The Y intercept.

$b_1, b_2, - - - - b_n$ = The multiple correlation coefficients.

e = An error term comprising the unaccounted variation in the dependent variable and the errors in the independent variables. This indicates the amount of scatter or variation about the regression line.

2. The Multiple Correlation Coefficient: - The multiple correlation coefficient R evaluates the strength of the relationship between the dependent variable and the linear composite of the independent variables. The value ranges from 0 to +1 and the higher its value, the stronger is the relationship between the dependent variable and the set of independent variables used in the explanation.

3. R^2: - This is also called the 'coefficient of multiple determination' and it represents the proportion of total variation in Y that is associated with or "explained by" variation in the independent

variables. It is the square of the multiple correlation coefficient.

4. Partial Regression Coefficient (b): - The partial regression coefficient indicates the net relationship between the dependent variable Y and each independent variable while taking into consideration other variables in the equation. A partial regression coefficient b_1 indicates the magnitude of expected change in Y (either increase or decrease) for a unit change in X_1 while controlling for or holding constant X_2, - - - - X_n.

5. Matrix of Correlation Coefficients: - This is a matrix of simple correlations among the variables. It enables us to evaluate the relative independence of the independent variables and to observe the strength of the relationship between Y and each X_i taken individually. These are presented in Appendix V.

STATISTICAL INFERENCE IN REGRESSION ANALYSIS

Although descriptive statistics obtained from regression analysis may be used on their own, it is often desirable to generalise to a population, especially when the regression analysis is based on a sample from the total population. This is done by testing statistical hypothesis about the population parameters based on results obtained from the sample. The F ratio hypothesis testing procedure is used to test the statistical significance of the regression analysis.

1. Significance Test for R: - This is a test for the overall statistical signficiance of the regression equation. It tests the hypothesis that the multiple correlation coefficient is zero in the population from which the sample was drawn.

$$\text{The F statistic} = \frac{\text{(Variation or total sum of squares in Y explained by the regression equation)}/k}{\text{(Variation or Residual sum of squares in Y unexplained by the regression equation)}/N-k-1}$$

distributed with k and N-k-1 degrees of freedom where,

N = Sample size, and

k = Number of independent variables in the equation.

2. Significance Test for the Regression Coefficients: - This is a test for the individual regression coefficients and is used to investigate the hypothesis that there is no linear relationship between the dependent variable and each independent variable. This test is made using,

$$\text{The F statistic} = \frac{\text{(Incremental variation or sum of squares in Y explained by } X_1)/1}{\text{(Variation or Residual sum of squares in Y unexplained by the regression equation)}/N-k-1}$$

distributed with 1 and N-k-1 degrees of freedom where,

N = Sample size, and

k = Number of independent variables in the equation.

APPENDIX V

CORRELATION MATRICES

CORRELATION MATRIX FOR TRIPS TO THE CENTRAL BUSINESS DISTRICT

TOTAL TRIPS	-																			
CHOICE MSPLIT	.00	-																		
O_i	.64	.00	-																	
D_j	.48	.06	-.04	-																
DIST	-.05	-.01	.03	.03	-															
AUTO	.14	.07	.17	-.00	.16	-														
PCOST	.20	.21	-.00	.39	.02	.03	-													
LOW RES	-.09	.10	-.03	.01	.42	.24	.02	-												
MED RES	.08	-.10	.02	-.01	-.39	-.28	-.03	-.98	-											
HIGH RES	.09	-.04	.05	.01	-.34	.06	.00	-.55	.39	-										
TOTAL MSPLIT	.11	.31	.02	.17	-.21	-.20	.29	-.12	.13	.02	-									
AUTOCAP MSPLIT	-.14	-.00	-.27	.04	.04	.06	.01	.05	-.04	-.05	-.16	-								
W TTIME	-.02	.19	.07	.07	.78	.04	.22	.39	-.36	-.33	.15	-.11	-							
LOG OF T_{ij}	.84	.05	.68	.43	.02	.18	.18	-.00	-.01	.06	.15	-.23	.11	-						
LOG OF O_i	.51	.06	.85	-.06	.08	.19	-.00	.03	-.04	.04	.07	-.15	.17	.71	-					
LOG OF D_j	.47	.05	-.05	.99	.03	.00	.39	.01	-.02	.01	.18	.04	.08	.43	-.06	-				
LOG OF DIST	-.04	.04	.05	.02	.93	.25	.02	.57	-.48	-.45	.45	-.16	.78	.06	.13	.02	-			
LOG OF AUTO	.16	.10	.22	-.00	.21	.97	.03	.26	-.30	.06	-.18	-.01	.11	.23	.27	.00	.32	-		
LOG OF PCOST	.07	.19	.01	.11	.02	.04	.94	.02	-.03	-.00	.26	-.00	-.22	-.07	.01	.14	.02	.03	-	
LOG OF W TTIME	.01	.19	.09	.05	.76	.13	.20	.48	-.43	-.41	.13	-.11	.94	.14	.21	.06	.86	.21	.21	-

Critical value of r significant at .05 level = $\pm .05$

CORRELATION MATRIX FOR TRIPS TO THE SOUTH EAST INDUSTRIAL ZONES

TOTAL TRIPS	-																			
CHOICE MSPLIT	.13	-																		
O_i	.38	.00	-																	
D_j	.25	.07	-.06	-																
DIST	-.42	-.09	-.03	.07	-															
AUTO	.16	-.03	.20	-.02	-.07	-														
PCOST	.11	-.01	-.00	.55	.03	.00	-													
LOW RES	.09	.02	-.03	-.01	.11	.25	-.02	-												
MED RES	-.09	-.02	.03	.01	-.09	-.29	.01	-.98	-											
HIGH RES	-.06	.02	.02	.01	-.15	.05	.03	-.55	.39	-										
TOTAL MSPLIT	.00	.47	-.02	.01	-.16	-.08	-.04	-.14	13	.11	-									
AUTOCAP MSPLIT	.14	-.00	-.20	.13	-.18	-.11	.09	.01	.00	-.04	-.06	-								
W TTIME	.39	.15	-.00	.09	.86	-.14	.05	.03	-.01	-.10	.25	-.19	-							
LOG OF T_{ij}	.89	.16	.41	.25	-.40	.18	.13	.11	-.11	-.07	.07	.15	-.35	-						
LOG OF O_i	.34	.03	.86	-.08	.02	.29	-.03	.07	-.09	.02	-.01	-.45	.03	.39	-					
LOG OF D_j	.25	.07	-.06	.98	.07	-.02	.50	-.01	.01	.01	.00	.13	.09	.25	-.08	-				
LOG OF DIST	-.44	-.08	-.02	.07	.95	-.06	.02	.06	-.05	-.10	-.14	-.23	.83	-.42	.02	.06	-			
LOG OF AUTO	.17	-.02	.23	-.03	-.03	.98	.00	.27	-.31	.03	-.07	-.11	-.10	.19	.32	-.03	-.05	-		
LOG OF PCOST	.11	.01	-.00	.48	.02	.01	.99	-.02	.01	.04	-.03	.09	.04	.13	-.03	.53	.01	.00	-	
LOG OF W TTIME	-.44	.11	-.01	.08	.87	-.12	.04	.01	.01	-.07	.18	-.26	.95	-.39	.04	.08	.91	-.09	.03	-

Critical value of r significant at .05 level = ±.05

CORRELATION MATRIX FOR TRIPS TO THE NORTH WEST INDUSTRIAL ZONES

TOTAL TRIPS	-																			
CHOICE MSPLIT	.09	-																		
O_i	.28	.01	-																	
D_j	.49	.10	-.09	-																
DIST	-.31	-.07	.16	-.39	-															
AUTO	-.01	-.08	.13	-.02	-.04	-														
PCOST	.26	.06	-.05	.53	-.11	-.04	-													
LOW RES	.01	-.04	-.05	-.03	-.12	.20	.00	-												
MED RES	-.01	.05	.04	.02	-.12	-.24	-.00	-.98	-											
HIGH RES	-.01	-.01	.05	.03	-.06	.08	-.01	-.54	.38	-										
TOTAL MSPLIT	.01	.39	.02	.09	-.05	-.17	.03	-.19	.18	.14	-									
AUTOCAP MSPLIT	.20	-.01	-.27	.15	-.12	-.06	.10	.03	-.03	-.05	-.05	-								
W. T. TIME	-.22	.17	.14	.13	.81	-.13	-.01	.03	-.02	.02	-.42	-.13	-							
LOG OF T_{ij}	.88	.13	.29	.48	-.32	-.02	.23	.01	-.01	-.28	.05	.18	-.20	-						
LOG OF O_i	.24	.04	.85	-.10	.13	.18	-.06	.01	-.02	.04	.01	-.52	.11	.27	-					
LOG OF D_j	.49	.09	-.09	.98	-.02	-.01	.48	-.02	.02	.03	.08	.16	.14	.48	-.10	-				
LOG OF DIST	-.31	-.06	.18	-.02	.95	-.06	-.08	.07	-.07	-.01	-.02	-.17	.80	-.31	.16	.00	-			
LOG OF AUTO	.02	-.07	.18	-.03	-.02	.97	-.05	.23	-.27	.07	-.19	-.06	-.13	.01	.24	-.02	-.05	-		
LOG OF PCOST	.22	.06	-.04	.46	-.11	-.05	.98	.01	-.00	-.01	.01	.09	-.02	.19	-.05	.39	-.08	-.05	-	
LOG OF W. T. TIME	-.20	.11	.17	.15	.84	-.11	.02	.00	-.00	.00	.30	-.15	.95	-.20	.15	.15	.88	.11	.01	-

Critical value of r significant at .05 level = ±.06

CORRELATION MATRIX FOR TRIPS TO THE NORTH EAST INDUSTRIAL ZONES

TOTAL TRIPS	-																			
CHOICE MSPLIT	.39	-																		
O_i	.34	.19	-																	
D_j	.15	.08	.01	-																
DIST	-.39	-.10	.08	.06	-															
AUTO	-.17	-.05	.17	.12	.39	-														
PCOST	.12	.08	.02	.85	.07	.14	-													
LOW RES	.07	.03	-.14	-.04	.01	.09	-.01	-												
MED RES	-.05	-.02	.15	.03	-.03	-.14	.00	-.98	-											
HIGH RES	-.11	-.03	.05	.03	.10	.18	.05	-.58	.42	-										
TOTAL MSPLIT	.22	.24	.04	.05	-.19	-.30	.09	.04	-.02	-.07	-									
AUTOCAP MSPLIT	-.02	-.01	-.25	.05	-.07	.25	.07	.07	-.07	-.04	-.04	-								
W TTIME	-.32	-.01	.10	.13	.92	.35	.15	-.00	-.02	.08	.06	-.11	-							
LOG OF T_{ij}	.90	.29	.38	.21	-.39	-.13	.19	.06	-.05	-.10	.27	-.06	-.29	-						
LOG OF O_i	.29	.12	.81	-.02	.09	.08	.01	-.87	.09	.05	.08	-.63	.13	.35	-					
LOG OF D_j	.15	.08	.01	.99	.06	.13	.89	-.03	.03	.04	.06	.05	.14	.21	-.06	-				
LOG OF DIST	-.42	-.13	.12	.07	.92	.42	.08	-.06	.04	.13	-.19	-.16	.87	-.39	.19	.08	-			
LOG OF AUTO	-.14	.04	.21	.10	.37	.98	.12	.12	-.17	.17	-.34	.14	.32	.10	.15	.11	.40	-		
LOG OF PCOST	.13	.08	.02	.91	.07	.14	.99	-.02	.01	.05	.08	.07	.15	.20	-.00	.95	.08	.12	-	
LOG OF W TTIME	-.33	-.04	.14	.15	.88	.36	.16	-.06	.04	.11	.06	.15	.96	-.28	.21	.15	.93	.32	.16	-

Critical value of r significant at .05 level = $\pm.07$

CORRELATION MATRIX FOR ALL THE INDUSTRIAL ZONES

TOTAL TRIPS	-																			
CHOICE MSPLIT	.13	-																		
O_i	.32	.03	-																	
D_j	.42	.08	-.07	-																
DIST	-.34	-.08	.07	.03	-															
AUTO	.04	-.05	.17	.00	.01	-														
PCOST	.04	.03	.01	.08	-.02	.00	-													
LOW RES	.05	-.01	-.05	-.02	.10	.21	-.01	-												
MED RES	-.04	.01	.05	.02	-.93	-.25	.01	-.98	-											
HIGH RES	-.04	-.00	.04	.02	-.07	.08	.02	-.55	.39	-										
TOTAL MSPLIT	.03	.41	.01	.06	-.11	-.15	-.01	-.14	.14	.10	-									
AUTOCAP MSPLIT	.15	-.01	-.24	.13	-.12	-.00	.00	.03	-.03	-.04	-.05	-								
W TTIME	-.28	.14	.07	.12	.85	-.07	-.00	.02	-.02	-.04	.31	-.13	-							
LOG OF T_{ij}	.89	.16	.35	.39	-.34	.05	.06	.06	-.05	-.05	.09	.11	-.26	-						
LOG OF O_i	.27	.05	.85	-.08	.08	.21	.01	.02	-.03	.03	.02	-.52	.09	.33	-					
LOG OF D_j	.40	.09	-.07	.96	.05	.01	.22	-.03	.03	.03	.06	.12	.13	.38	-.07	-				
LOG OF DIST	-.35	-.07	.09	.04	.95	.01	-.01	.05	-.05	-.05	-.09	-.17	-.82	-.35	.12	.06	-			
LOG OF AUTO	.06	-.05	.21	-.02	.03	.97	-.00	.24	-.27	.07	-.16	-.03	-.06	.08	.26	-.00	.02	-		
LOG OF PCOST	.07	.04	-.00	.15	-.05	-.00	.94	-.01	.00	.01	.00	.02	-.01	.07	-.00	.26	-.03	-.01	-	
LOG OF W TTIME	-.29	.10	.09	.13	.86	-.05	-.00	-.00	.01	-.02	.22	-.17	.15	-.27	.12	.14	.90	-.05	.00	-

Critical value of r significant at .05 level = $\pm .02$

CORRELATION MATRIX FOR ALL THE FOUR EMPLOYMENT CENTERS

TOTAL TRIPS	-																			
CHOICE MSPLIT	.27	-																		
O_i	.33	-.02	-																	
D_j	.68	.39	-.09	-																
DIST	-.26	-.16	.08	-.21	-															
AUTO	.08	.00	.17	-.00	.05	-														
PCOST	.50	.41	-.06	.73	-.19	.01	-													
LOW RES	-.04	.03	-.04	-.01	.17	.22	.00	-												
MED RES	.03	-.03	.04	.01	-.16	-.26	-.00	-.98	-											
HIGH RES	.04	-.01	.04	.02	-.14	.07	.01	-.55	.39	-										
TOTAL MSPLIT	.35	.44	-.03	.49	-.23	-.13	.52	-.09	.09	.03	-									
AUTOCAP MSPLIT	-.04	-.01	-.25	.04	-.06	.02	.01	.04	-.03	-.04	-.10	-								
W TTIME	.02	.21	.06	.18	.73	-.03	.20	14	-.12	-.13	.20	-.12	-							
LOG OF T_{ij}	.82	.34	.33	.65	-.35	.08	.50	.02	-.03	.00	.37	-.03	-.00	-						
LOG OF O_i	.27	.01	.85	-.10	.10	.20	-.06	.02	-.04	.04	-.01	-.51	.10	.33	-					
LOG OF D_j	.62	.40	.10	.92	-.21	.00	.69	-.02	.01	.03	.46	.05	.21	.68	-.11	-				
LOG OF DIST	-.22	-.12	.09	-.16	.94	.09	-.15	.20	-.18	-.17	-.19	-.09	.74	-.29	.14	-.16	-			
LOG OF AUTO	.09	.01	.21	-.02	.08	.97	.00	.25	-.28	.06	-.13	-.02	-.00	.10	.26	-.01	.12	-		
LOF OF PCOST	.44	.39	-.06	.64	-.22	.01	.88	-.01	.00	.02	.46	.01	.17	.48	-.06	.69	-.16	-.01	-	
LOG OF W TTIME	.03	.19	.08	.18	.74	.01	.19	.15	-.13	-.14	.18	-.14	.95	-.00	.13	.21	.82	.04	.17	-

Critical value of r significant at .05 level = ±.02

CORRELATION MATRIX FOR ALL THE EMPLOYMENT CENTERS WITH CENTRAL BUSINESS DISTRICT/INDUSTRIAL ZONE LOCATION SPECIFIED.

TOTAL TRIPS	-																				
CHOICE MSPLIT	.27	-																			
O_i	.33	-.02	-																		
D_j	.68	.39	-.09	-																	
DIST	-.26	-.16	.08	-.21	-																
AUTO	.08	.00	.17	-.00	.05	-															
PCOST	.50	.41	-.06	.73	-.20	.01	-														
LOW RES	-.04	.03	-.04	-.01	.18	.22	.00	-													
MED RES	.03	-.03	.04	.01	-.16	-.26	-.00	-.98	-												
HIGH RES	.04	-.01	.04	.02	-.14	.07	.01	-.55	.39	-											
TOTAL MSPLIT	.35	.44	-.03	.49	-.23	-.13	.52	-.09	.09	.03	-										
AUTOCAP MSPLIT	-.04	-.01	-.25	.04	-.06	.02	.01	.04	-.03	-.04	-.10	-									
W TTIME	.02	.21	.06	.18	.73	-.03	.20	.14	-.12	-.13	.20	-.12	-								
LOG OF T_{ij}	.82	.34	.33	.66	-.35	.08	.50	.02	-.03	.00	.37	-.03	-.00	-							
LOG OF O_i	.27	.01	.85	-.10	.10	.20	-.06	.02	-.04	.04	-.01	-.51	.10	.33	-						
LOG OF D_j	.62	.40	-.10	.92	-.21	.00	.69	-.02	.01	.03	.46	.05	.21	.68	-.11	-					
LOG OF DIST	-.22	-.12	.10	.16	.94	.09	-.15	.20	-.18	-.17	-.19	-.09	.74	-.29	.13	-.16	-				
LOG OF AUTO	.09	.01	.21	-.02	.08	.97	.00	.25	-.28	.06	-.13	-.02	-.00	.10	.26	-.01	.12	-			
LOG OF PCOST	.44	.39	-.06	.64	-.22	.01	.88	-.01	.00	.02	.46	.01	.17	.48	-.06	.69	-.16	-.01	-		
LOG OF W TTIME	.03	.19	.08	.18	.74	.01	.19	.15	-.13	-.14	.18	-.14	.95	-.00	.13	.21	.82	.04	.17	-	
D_i	.55	.44	-.08	.81	-.28	-.00	.71	-.01	.09	.02	.50	.00	.17	.60	-.09	.84	-.22	-.01	.73	.17	-

Critical value of r significant at .05 level = ±.02

CORRELATION MATRIX FOR ALL THE EMPLOYMENT CENTERS WITH EACH DESTINATION AREA SPECIFIED

TOTAL TRIPS	-																						
CHOICE MSPLIT	.27	-																					
O_i	.33	-.02	-																				
D_j	.66	.39	-.09	-																			
DIST	-.26	-.16	.08	-.21	-																		
AUTO	.08	.00	.17	-.00	.05	-																	
PCOST	.50	.41	-.06	.73	-.20	.01	-																
LOW RES	-.40	.03	-.04	-.01	.18	.22	.00	-															
MED RES	.03	-.03	.04	.01	-.16	-.26	-.00	-.98	-														
HIGH RES	.04	-.01	.04	.02	-.14	.07	.01	-.55	.39	-													
TOTAL MSPLIT	.35	.44	-.03	.49	-.23	-.13	.52	-.09	.09	.04	-												
AUTOCAP MSPLIT	-.04	-.01	-.25	.04	-.06	.02	.01	.04	-.03	-.04	-.10	-											
W TTIME	.02	.21	.06	.18	.73	-.03	.20	.14	-.12	-.13	.20	-.12	-										
LOG OF T_{ij}	.82	.34	.33	.65	-.35	.08	.50	.02	-.03	.00	.37	-.03	-.00	-									
LOG OF O_i	.27	.01	.85	-.10	.10	.20	-.06	.02	-.04	.04	-.01	-.51	.10	.33	-								
LOG OF D_j	.62	.40	-.10	.92	-.21	.00	.69	-.02	.01	.03	.46	.05	.21	.68	-.11	-							
LOG OF DIST	-.22	-.12	.09	.16	.94	.09	-.15	.20	-.18	-.17	-.19	-.09	.74	-.29	.14	-.16	-						
LOG OF AUTO	.09	.01	.21	-.02	.08	.97	.00	.25	-.28	.06	-.13	-.02	-.00	.10	.26	-.01	.12	-					
LOG OF PCOST	.44	.39	-.06	.64	-.22	.01	.88	-.01	.00	.02	.46	.01	.17	.48	-.06	.69	-.16	-.01	-				
LOG OF W TTIME	.03	.19	.08	.18	.74	.01	.19	.15	-.13	-.14	.18	-.14	.95	-.00	.13	.21	.81	.04	.17	-			
D_1	-.26	-.18	.05	-.39	.13	.01	-.21	-.00	.00	.00	-.22	.04	-.09	-.28	.07	-.38	.11	.01	-.01	-.09	-		
D_2	-.23	-.20	.03	-.33	.17	.02	-.43	.00	-.00	-.01	-.23	.03	-.03	-.23	.03	-.31	.14	.02	-.65	-.40	-.40	-	
D_3	-.15	-.12	.01	-.22	-.03	-.03	-.16	.02	-.02	-.02	-.11	.01	-.10	-.19	-.01	-.29	-.04	-.02	-.16	-.19	-.20	-.09	-

Critical value of r significant at .05 level = ±.02

APPENDIX VI

SOME OF THE MODELS OBTAINED FROM THE ANALYSIS

APPENDIX VI (a)

CENTRAL BUSINESS DISTRICT

1. Multiple R = .819 F(5,1040) = 422. α = .0005 R^2 = .670

Variables	b	F(1,1040)	α
O_i	.0470	1295.	.0005
D_j	.00662	788.	.0005
DIST	-.0831	22.4	.0005
AUTO	10.9	4.74	.05
TOTAL MSPLIT	-.0526	.046	NOT SIG.

Constant -19.3

2. Multiple R = .819 F(5,1040) = 423. α = .0005 R^2 = .671

Variables	b	F(1,1040)	α
O_i	.0475	1222.	.0005
D_j	.00660	813.	.0005
DIST	-.0832	23.3	.0005
AUTO	10.4	4.44	.05
AUTOCAP MSPLIT	6.93	1.84	.25

Constant -19.4

APPENDIX VI (a) - Continued

3. Multiple R = .820 F(6,1039) = 355. α = .0005 R^2 = .672

Variables	b	F(1,1039)	α
O_i	.0469	1302.	.0005
D_j	.00662	819.	.0005
DIST	-.0729	15.7	.0005
AUTO	11.1	5.03	.025
CHOICE MSPLIT	-1.65	2.91	.10
HIGH RES	12.0	2.32	.25

Constant -19.5

4. Multiple R = .821 F(5,1040) = 429. α = .0005 R^2 = .674

Variables	b	F(1,1040)	α
O_i	.0466	1291.	.0005
D_j	.00661	823.	.0005
DIST	-.0573	9.37	.005
LOW RES	-5.5	11.0	.001

Constant -16.8

APPENDIX VI (a) - Continued

5. Multiple $R = .822$ $F(5,1040) = 433.$ $\alpha = .0005$ $R^2 = .676$

Variables	b	F(1,1040)	α
O_i	.0471	1309.	.0005
D_j	.00665	836.	.0005
WEIGHTED T. TIME	-.205	15.5	.0005
AUTO	12.2	6.03	.025
LOW RES	-4.90	8.94	.005

Constant -15.3

6. Multiple $R = .821$ $F(5,1040) = 429.$ $\alpha = .0005$ $R^2 = .674$

Variables	b	F(1,1040)	α
O_i	.0467	1292.	.0005
D_j	.00661	824.	.0005
DIST	-.0601	10.6	.0005
AUTO	15.4	9.35	.005
MED RES	5.90	10.7	.005

Constant -22.4

APPENDIX VI (a) - Continued

7. Multiple R = .822 F(5,1040) = 433. α = .0005 R^2 = .676

Variables	b	F(1,1040)	α
O_i	.0471	1311.	.0005
D_j	.00666	837.	.0005
WEIGHTED T. TIME	-.211	16.9	.0005
AUTO	12.8	6.45	.025
MED RES	5.33	8.73	.005

Constant -20.3

APPENDIX VI (b) - Continued

3. Multiple $R = .669$ $F(6,852) = 115.$ $\alpha = .0005$ $R^2 = .443$

Variables	b	F(1,852)	α
O_i	.00754	245.	.0005
D_j	.00612	130.	.0005
DIST	-.0635	242.	.0005
AUTO	2.52	1.52	.25
AUTOCAP MSPLIT	23.5	30.6	.0005
MED RES	-3.01	24.6	.0005

Constant .753

4. Multiple $R = .670$ $F(6,852) = 116.$ $\alpha = .0005$ $R^2 = .449$

Variables	b	F(1,852)	α
O_i	.00736	235.	.0005
D_j	.00614	131.	.0005
DIST	-.0644	246.	.0005
AUTO	6.02	9.58	.005
AUTOCAP MSPLIT	23.0	29.3	.0005
HIGH RES	-14.2	26.4	.0005

Constant -.508

APPENDIX VI (b)

SOUTH EAST INDUSTRIAL ZONES

1. Multiple R = .644 F(5,853) = 121. α = .0005 R^2 = .415

Variables	b	F(1,853)	α
O_i	.00683	198.	.0005
D_j	.00634	133.	.0005
DIST	-.0647	248.	.0005
AUTO	4.94	6.14	.025
CHOICE MSPLIT	1.29	6.98	.01

Constant .038

2. Multiple R = .643 F(5,853) = 120. α = .0005 R^2 = .413

Variables	b	F(1,853)	α
O_i	.00683	197.	.0005
D_j	.00648	140.	.0005
DIST	-.067	262.	.0005
AUTO	4.39	4.80	.05
TOTAL MSPLIT	-1.04	4.07	.05

Constant .434

APPENDIX VI (b) - Continued

5. Multiple R = .6 F(5,853) = 140. α = .0005 R^2 = .4

Variables	b	F(1,853)	α
O_i	.00766	262.	.0005
D_j	.00613	130.	.0005
DIST	-.0640	249.	.0005
AUTOCAP MSPLIT	23.0	29.6	.0005
MED RES	-3.24	31.6	.0005

Constant 1.62

APPENDIX VI (c)

NORTH WEST INDUSTRIAL ZONES

1. Multiple $R = .695$ $F(6,906) = 141.$ $\alpha = .0005$ $R^2 = .483$

Variables	b	F(1,906)	α
O_i	.00907	263.	.0005
D_j	.00634	368.	.0005
DIST	-.0694	222.	.0005
AUTO	-7.04	9.57	.005
PCOST	- .0121	3.41	.10
CHOICE MSPLIT	.237	.151	NOT SIG.

Constant 4.09

2. Multiple $R = .699$ $F(6,906) = 144.$ $\alpha = .0005$ $R^2 = .488$

Variables	b	F(1,906)	α
O_i	.00919	273.	.0005
D_j	.00645	384.	.0005
DIST	-.0705	231.	.0005
AUTO	-8.408	13.4	.0005
PCOST	-.0129	3.91	.05
TOTAL MSPLIT	-1.594	9.62	.005

Constant 4.66

APPENDIX VI (c) - Continued

3. Multiple R = .723 F(7,905) = 141. α = .0005 R^2 = .522

Variables	b	F(1,905)	α
O_i	.0103	343.	.0005
D_j	.00610	366.	.0005
DIST	-.0674	225.	.0005
AUTO	-6.25	8.16	.005
PCOST	-.0130	4.23	.05
AUTOCAP MSPLIT	21.9	67.4	.0005
HIGH RES	-7.77	6.33	.025

Constant 3.12

APPENDIX VI (d)

NORTH EAST INDUSTRIAL ZONES

1. Multiple R = .584 $F(5,264) = 27.4$ $\alpha = .0005$ $R^2 = .342$

Variables	b	F(1,264)	α
O_i	.00558	54.8	.0005
D_j	.00541	12.3	.0005
DIST	-.0487	49.9	.0005
AUTO	-4.66	1.61	.25
TOTAL MSPLIT	1.61	3.68	.10

Constant 2.98

2. Multiple R = .581 $F(5,264) = 26.9$ $\alpha = .0005$ $R^2 = .338$

Variables	b	F(1,264)	α
O_i	.00607	59.1	.0005
D_j	.00564	13.4	.0005
DIST	-.0479	46.6	.0005
AUTO	-8.45	4.95	.05
AUTOCAP MSPLIT	4.00	2.08	.25

Constant 3.94

APPENDIX VI (d) - Continued

3. Multiple R = .644 $F(6,263) = 31.1$ $\alpha = .0005$ $R^2 = .415$

Variables	b	F(1,263)	α
O_i	.00526	51.2	.0005
D_j	.00517	12.5	.0005
DIST	-.0461	50.1	.0005
AUTO	-7.19	4.47	.05
CHOICE MSPLIT	6.02	27.8	.0005
MED RES	-2.95	7.21	.01

Constant 4.19

4. Multiple R = .636 $F(6,263) = 29.8$ $\alpha = .0005$ $R^2 = .405$

Variables	b	F(1,263)	α
O_i	.00493	45.6	.0005
D_j	.00497	11.4	.001
DIST	-.0461	49.1	.0005
AUTO	-4.86	2.02	.25
CHOICE MSPLIT	6.20	29.0	.0005
HIGH RES	-7.19	2.3	.25

Constant 3.36

APPENDIX VI (e)

COMBINATION OF THE FOUR EMPLOYMENT CENTRES WITH CBD/INDUSTRIAL DESTINATION SPECIFIED (LINEAR)

1. Multiple R = .781 F(3,3083) = 1605. α = .0005 R^2 = .610

Variables	b	F(1,3083)	α
O_i	.0212	1185.	.0005
D_j	.00641	1329.	.0005
D1	-.211	.171	NOT SIG.

Constant -8.18

2. Multiple R = .793 F(4,3082) = 1306. α = .0005 R^2 = .629

Variables	b	F(1,3082)	α
O_i	.0216	1295.	.0005
D_j	.00646	1416.	.0005
DIST	-.0718	159.	.0005
D1	. 928	3.38	.25

Constant -5.40

3. Multiple R = .792 F(4,3082) = 1300. α = .0005 R^2 = .628

Variables	b	F(1,3082)	α
O_i	.0217	1301.	.0005
D_j	.00657	1455.	.0005

APPENDIX VI (e) - Continued

W TTIME	-.254	151.	.0005
D1	-.476	.914	NOT SIG.

Constant -4.02

4. Multiple R = .793 F(5,3081) = 1046. α = .0005 R^2 = .629

Variables	b	F(1,3081)	α
O_i	.0214	1240.	.0005
D_j	.00646	1416.	.0005
DIST	-.0722	161.	.0005
AUTO	4.10	2.85	.05
D1	.935	3.43	.10

Constant -6.70

5. Multiple R = .793 F(6,3080) = 871. α = .0005 R^2 = .629

Variables	b	F(1,3080)	α
O_i	.0214	1239.	.0005
D_j	.00642	1212.	.0005
DIST	-.0721	161.	.0005
AUTO	4.07	2.82	.10
PCOST	.00051	.375	NOT SIG.
D1	1.03	3.81	.10

Constant -6.81

APPENDIX VI (e) - Continued

6. Multiple R = .793 F(6,3080) = 871. α = .0005 R^2 = .629

Variables	b	F(1,3080)	α
O_i	.0215	1241.	.0005
D_j	.00647	1415.	.0005
DIST	-.0724	162.	.0005
AUTO	4.11	2.87	.10
CHOICE MSPLIT	-.519	.855	NOT SIG.
D1	.832	2.59	.25

Constant -6.57

7. Multiple R = .793 F(6,3080) = 871. α = .0005 R^2 = .629

Variables	b	F(1,3080)	α
O_i	.0214	1236.	.0005
D_j	.00646	1376.	.0005
DIST	-.0722	159.	.0005
AUTO	4.07	2.75	.10
TOTAL MSPLIT	-.0113	.004	NOT SIG.
D1	.929	3.28	.10

Constant -6.69

APPENDIX VI (e) - Continued

8. Multiple $R = .794$ $F(6,3080) = 873.$ $\alpha = .0005$ $R^2 = .630$

Variables	b	F(1,3080)	α
O_i	.0217	1194.	.0005
D_j	.00644	1407.	.0005
DIST	-.0716	158.	.0005
AUTO	3.77	2.41	.25
AUTOCAP MSPLIT	5.34	3.57	.10
D1	.878	3.02	.10

Constant -6.77

9. Multiple $R = .793$ $F(5,3081) = 1046.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3081)	α
O_i	.0219	1253.	.0005
D_j	.00644	1407.	.0005
DIST	-.0712	156.	.0005
AUTOCAP MSPLIT	5.66	4.02	.05
D1	.868	2.95	.10

Constant -5.58

APPENDIX VI (e) - Continued

10. Multiple R = .793 F(6,3080) = 872. α = .0005 R^2 = .629

Variables	b	F(1,3080)	α
O_i	.0219	1253.	.0005
D_j	.00644	1407.	.0005
DIST	-.0721	155.	.0005
AUTOCAP MSPLIT	5.56	3.88	.05
LOW RES	.624	.780	NOT SIG.
D1	.881	3.04	.10

Constant -6.09

11. Multiple R = .793 F(6,3080) = 872. α = .0005 R^2 = .629

Variables	b	F(1,3080)	α
O_i	.0219	1254.	.0005
D_j	.00644	1407.	.0005
DIST	-.0720	156.	.0005
AUTOCAP MSPLIT	5.58	3.90	.05
MED RES	-.676	.755	NOT SIG.
D1	.879	3.03	.10

Constant -5.47

APPENDIX VI (e) - Continued

12. Multiple $R = .793$ $F(6,3080) = 872.$ $\alpha = .0005$ $R^2 = .629$

Variables	b	F(1,3080)	α
O_i	.0219	1252.	.0005
D_j	.00644	1406.	.0005
DIST	-.0716	155.	.0005
AUTOCAP MSPLIT	5.60	3.93	.05
HIGH RES	-1.67	.221	NOT SIG.
D1	.874	2.99	.10

Constant -5.55

APPENDIX VI (f)

ALL WORK TRIPS IN THE CITY WITH CBD/INDUSTRIAL DESTINATION SPECIFIED (LOG)

1. Multiple R = .792 F(3,3083) = 1725. α = .0005 R^2 = .627

Variables	b	F(1,3083)	α
Log of O_i	.556	1358.	.0005
Log of D_j	.728	969.	.0005
D1	-.122	33.0	.0005

Constant -2.77

2. Multiple R = .825 F(4,3082) = 1647. α =.0005 R^2 = .681

Variables	b	F(1,3082)	α
Log of O_i	.595	1797.	.0005
Log of D_j	.756	1221.	.0005
Log of DIST	-.483	528.	.0005
D1	-.0480	5.86	.025

Constant -2.20

3. Multiple R = .820 F(4,3082) = 1583. α = .0005 R^2 = .673

Variables	b	F(1,3082)	α
Log of O_i	.603	1755.	.0005
Log of D_j	.788	1274.	.0005
Log of W TTIME	-.561	432.	.0005

APPENDIX VI (f) - Continued

D1	-.119	36.1	.0005

Constant -2.39

4. Multiple R = .826 F(5,3081) = 1321. α = .0005 R^2 = .682

Variables	b	F(1,3081)	α
Log of O_i	.587	1636.	.0005
Log of D_j	.756	1221.	.0005
Log of DIST	-.488	535.	.0005
Log of AUTO	.147	5.70	.025
D1	-.0477	5.79	.025

Constant -2.09

5. Multiple R =.862 F(6,3080) = 1103. α = .0005 R^2 = .682

Variables	b	F(1,3080)	α
Log of O_i	.588	1641.	.0005
Log of D_j	.766	1198.	.0005
Log of DIST	-.489	538.	.0005
Log of AUTO	.148	5.77	.025
Log of PCOST	-.040	5.09	.025
D1	-.0659	9.50	.005

Constant -2.03

APPENDIX VII

COMPARISON OF PREDICTED WORK TRIPS WITH ACTUAL WORK TRIPS

COMPARISON OF PREDICTED WORK TRIPS WITH ACTUAL

WORK TRIPS TO THE CENTRAL BUSINESS DISTRICT

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
1	11	11	35	39	40	125	14	16
2	95	133	160	160	172	200	135	149
3	29	31	51	37	39	126	26	29
4	271	197	211	206	209	241	182	177
5	250	220	242	234	238	266	219	219
6	528	452	468	475	476	299	332	341
7	430	330	365	345	349	355	280	291
8	507	539	550	519	526	498	474	454
9	358	382	405	353	360	407	343	339
10	495	408	475	443	474	650	416	424
11	414	364	363	336	350	583	386	360
12	232	291	267	228	239	398	266	243
13	506	503	439	414	427	526	493	446
19	291	322	289	283	288	262	293	251
20	169	196	181	170	174	215	156	143
21	379	463	451	433	438	345	389	360
22	315	395	372	366	370	316	341	310
26	187	203	186	186	190	222	206	188
27	505	478	473	462	468	431	435	407
28	364	341	336	323	330	368	332	310
32	427	470	437	408	491	474	460	421
33	341	365	340	324	331	330	328	298
36	1	- 11	- 12	- 10	- 10	- 1	0	0

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
39	-	-	-	-	-	-	-	-
40	12	34	28	23	36	95	19	17
41	426	467	464	496	504	495	443	414
42	245	116	107	84	92	270	124	116
43	566	474	493	478	489	524	460	419
44	850	635	678	704	720	619	544	553
45	621	470	535	587	610	565	456	475
46	735	657	674	585	685	678	616	588
47	496	690	650	624	643	824	674	620
49	793	878	827	811	821	748	812	740
50	715	655	632	668	669	530	606	562
51	612	599	526	536	547	548	563	505
59	121	103	76	81	88	192	121	109
60	148	140	156	156	162	235	141	138
61	218	298	300	310	314	309	266	247
62	76	104	98	109	111	114	106	97
63	335	363	353	312	317	347	335	312
64	178	185	172	176	178	144	164	148
65	527	653	609	611	620	539	555	502
68	273	375	371	376	385	484	361	339
69	631	738	765	736	748	723	677	657
70	592	643	675	679	686	547	554	555
71	28	26	33	25	28	94	33	32
72	362	403	439	400	418	500	338	383
73	501	461	462	469	474	424	393	387
74	542	482	514	502	515	655	492	477

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
75	737	663	662	646	655	591	599	566
78	703	723	727	709	715	550	600	571
79	-	-	-	-	-	-	-	-
82	388	481	491	469	477	518	467	446
83	400	493	503	485	490	444	422	407
84	-	-	-	-	-	-	-	-
85	2	24	23	10	11	43	1	1
86	1	4	4	5	5	14	0	0
89	1	0	- 3	0	0	7	0	0
TOTAL	19,940	20,120	20,126	19,596	20,182	21,006	18,448	17,559
DIFFERENCE		+ 160	+ 189	- 344	+ 242	+ 1066	- 1492	- 2381
% DIFFERENCE OF TOTAL		+ 0.8%	+ .9%	- 1.7%	+ 1.2%	+ 5.4%	- 7.5%	-11.9%

Model No. 1 $T_{ij} = -19.2 + .0473\, O_i + .00658\, D_j$

Model No. 2 $T_{ij} = -16.1 + .0475\, O_i + .00661\, D_j - .0758\ \text{DIST}$

Model No. 3 $T_{ij} = -22.4 + .0467\, O_i + .00663\, D_j - .0617\ \text{DIST} + 15.8\ \text{AUTO} - 1.45\ \text{CHOICE MSPLIT} + 5.6\ \text{MED RES}$

Model No. 4 $T_{ij} = -16.7 + .0466\, O_i + .00663\, D_j - .0590\ \text{DIST} + 15.1\ \text{AUTO} - 1.43\ \text{CHOICE MSPLIT} - 5.2\ \text{LOW RES}$

Model No. 5 $T_{ij} = -4.55 + .0216\, O_i + .00621\, D_j - .0699\ \text{DIST}$

Model No. 6 $T_{ij} = -4.16 + .785\, O_i + .969\, D_j$

Model No. 7 $T_{ij} = -4.04 + .792\, O_i + .972\, D_j - .0947\ \text{DIST}$

COMPARISON OF PREDICTED WORK TRIPS WITH ACTUAL

WORK TRIPS TO THE SOUTH EAST INDUSTRIAL ZONES

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
1	1	1	1	- 1	1	- 5	1	1
2	22	30	48	28	44	12	24	31
3	4	5	9	3	7	- 26	4	4
4	15	38	29	25	29	39	28	22
5	25	45	40	38	39	19	38	32
6	44	109	105	112	110	236	53	48
7	25	76	78	58	78	108	51	48
8	56	109	87	87	88	119	80	64
9	47	81	74	76	74	86	61	47
10	59	93	107	67	102	34	78	77
11	58	91	72	74	67	- 20	70	59
12	30	49	35	37	34	19	37	28
13	92	110	36	32	34	- 39	95	63
19	48	70	22	19	23	32	53	34
20	10	24	16	15	16	20	18	13
21	43	83	57	58	59	57	55	39
22	47	93	45	40	48	85	65	43
26	7	21	8	4	7	- 4	17	11
27	47	82	45	37	45	51	62	44
28	31	76	34	32	33	12	60	41
32	53	90	14	10	13	- 25	76	47
33	34	60	22	17	23	36	45	28
36	-	-	-	-	-	-	-	-

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
39	-	-	-	-	-	-	-	-
40	1	2	1	1	1	- 5	1	1
41	48	92	54	34	53	34	71	52
42	24	21	- 1	2	3	- 61	19	14
43	51	89	61	54	60	44	72	55
44	42	113	112	93	114	190	70	64
45	48	91	99	50	96	91	70	70
46	78	123	85	85	84	83	96	73
47	120	152	31	18	28	- 62	129	82
49	123	184	103	95	103	106	148	105
50	43	90	61	63	60	45	71	54
51	63	113	80	79	80	85	85	65
59	25	26	24	23	21	- 27	24	21
60	24	28	43	41	40	3	25	31
61	70	78	98	93	95	67	62	69
62	38	27	36	34	35	20	24	27
63	123	84	116	123	114	131	63	90
64	55	43	41	45	42	57	31	28
65	242	161	120	195	189	267	106	119
68	222	100	164	159	160	142	82	156
69	232	177	267	277	262	276	135	229
70	209	153	208	195	208	290	105	168
71	9	5	13	14	12	- 9	5	9
72	176	107	165	174	160	126	86	122
73	148	115	147	148	145	181	81	99
74	155	131	170	170	162	66	117	125

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
75	218	160	155	164	155	186	120	110
78	332	169	195	209	196	313	109	133
79	-	-	-	-	-	-	-	-
82	279	131	228	239	221	187	109	227
83	241	122	173	187	173	237	83	148
84	3	1	5	6	5	- 1	0	2
85	2	2	7	8	6	- 6	1	1
86	-	-	-	-	-	-	-	-
89	-	-	-	-	-	-	-	-
TOTAL	4,242	4,326	4,105	3,946	4,057	3,902	3,271	3,373
DIFFERENCE		+ 84	- 137	- 296	- 185	- 340	- 971	- 869
% DIFFERENCE OF TOTAL		+1.96%	-3.2%	-7.0%	-4.4%	-8.0%	-22.9%	-20.5%

Model No. 1 $T_{ij} = -1.91 + .00728\ O_i + .00580\ D_j$

Model No. 2 $T_{ij} = 1.72 + .00707\ O_i + .00645\ D_j - .00663\ \text{DIST}$

Model No. 3 $T_{ij} = -1.50 + .00766\ O_i + .00615\ D_j - .0648\ \text{DIST} + 3.19\ \text{LOW RES}$

$+ 22.7\ \text{AUTOCAP MSPLIT}$

Model No. 4 $T_{ij} = 1.45 + .00761\ O_i + .00612\ D_j - .0642\ \text{DIST}$

Model No. 5 $T_{ij} = -4.55 + .0216\ O_i + .00621\ D_j - .0699\ \text{DIST}$

Model No. 6 $T_{ij} = -2.29 + .489\ O_i + .564\ D_j$

Model No. 7 $T_{ij} = -1.35 + .505\ O_i + .628\ D_j - .678\ \text{DIST}$

COMPARISON OF PREDICTED WORK TRIPS WITH ACTUAL

WORK TRIPS TO THE NORTH WEST INDUSTRIAL ZONES

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
1	2	6	5	6	6	- 6	2	2
2	25	34	33	24	34	17	27	25
3	6	11	10	12	11	- 6	5	5
4	23	38	43	45	42	46	29	29
5	51	52	71	67	71	51	44	56
6	127	103	128	132	117	231	46	62
7	56	72	86	88	84	94	47	53
8	111	116	111	120	108	137	84	78
9	67	79	84	99	82	93	59	59
10	60	88	81	71	84	42	70	64
11	47	72	44	42	49	1	59	47
12	55	76	40	47	44	2	54	40
13	85	119	63	63	66	41	86	62
19	102	83	40	45	41	48	62	45
20	58	40	20	31	21	8	32	25
21	112	113	90	102	85	141	67	57
22	115	97	69	74	66	101	66	52
26	61	55	38	34	40	12	47	29
27	129	112	111	115	109	126	83	79
28	87	90	96	98	97	78	71	73
32	169	120	152	163	152	119	100	122
33	149	112	135	148	132	138	71	96
36	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
40	10	12	27	33	29	- 9	10	20
41	203	128	208	186	205	174	104	194
42	116	41	75	126	79	- 2	37	55
43	198	126	190	188	188	165	106	156
44	123	155	194	168	186	248	95	115
45	77	107	125	82	123	116	81	86
46	227	166	256	251	250	253	126	226
47	383	194	321	334	320	219	164	284
49	435	230	302	322	295	302	177	213
50	190	164	211	187	208	188	129	155
51	227	160	163	162	162	147	121	117
59	14	19	13	10	15	- 7	18	15
60	3	21	22	18	23	12	15	14
61	15	53	49	42	49	47	40	37
62	22	30	15	6	16	- 1	26	20
63	32	58	43	43	43	48	43	34
64	22	40	22	20	21	32	29	20
65	58	133	84	81	82	120	84	62
68	46	81	50	39	52	37	62	49
69	75	155	124	120	123	131	115	96
70	64	123	115	107	110	164	83	74
71	4	12	10	9	11	0	7	5
72	44	88	62	58	64	41	69	54
73	45	81	55	67	62	100	53	43
74	46	110	63	55	69	19	89	66
75	71	138	76	75	76	99	100	71

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
78	72	145	104	108	98	175	95	70
79	-	-	-	-	-	-	-	-
82	58	111	65	62	68	46	88	66
83	51	99	74	76	72	99	66	50
84	3	6	3	13	4	- 3	1	1
85	-	-	-	-	-	-	-	-
86	2	5	- 6	2	- 3	- 16	0	1
89	-	-	-	-	-	-	-	-
TOTAL	4,633	4,679	4,665	4,676	4,639	4,458	3,444	3,629
DIFFERENCE		+ 46	+ 32	+ 43	+ 6	- 175	-1,188	-1,004
% DIFFERENCE OF TOTAL		+.99%	+0.7%	+0.9%	+0.1%	-3.8%	-25.7%	-21.7%

Model No. 1 $T_{ij} = -2.29 + .00750\ O_i + .00613\ D_j$

Model No. 2 $T_{ij} = 1.22 + .00881\ O_i + .00603\ D_j - .0676\ \text{DIST}$

Model No. 3 $T_{ij} = 1.68 + .0104\ O_i + .00613\ D_j - .0695\ \text{DIST} - 8.72\ \text{AUTO} - .0137\ \text{PCOST} + 2.62\ \text{LOW RES} + 21.7\ \text{AUTOCAP MSPLIT}$

Model No. 4 $T_{ij} = 1.45 + .00761\ O_i + .00612\ D_j - .0642\ \text{DIST}$

Model No. 5 $T_{ij} = -4.55 + .0216\ O_i + .00621\ D_j - .0699\ \text{DIST}$

Model No. 6 $T_{ij} = -2.34 + .374\ O_i + .698\ D_j$

Model No. 7 $T_{ij} = -1.52 + .442\ O_i + .707\ D_j - .595\ \text{DIST}$

COMPARISON OF PREDICTED WORK TRIPS WITH ACTUAL

WORK TRIPS TO THE NORTH EAST INDUSTRIAL ZONES

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
1	1	1	0	0	1	- 7	1	1
2	1	2	2	1	2	1	1	1
3	-	-	-	-	-	-	-	-
4	26	21	28	26	30	27	12	18
5	13	17	21	19	22	13	12	16
6	27	39	41	41	52	118	13	16
7	19	30	36	31	31	54	17	22
8	107	54	82	99	92	109	30	71
9	35	28	40	45	45	50	16	32
10	40	33	45	48	46	13	23	35
11	64	38	65	68	57	25	26	55
12	64	32	61	71	63	6	23	56
13	102	52	71	71	76	55	31	51
19	67	33	45	49	50	58	19	31
20	57	18	30	36	33	33	9	25
21	93	43	62	74	73	111	21	49
22	39	35	47	53	54	75	18	31
26	20	20	26	23	27	13	14	19
27	60	43	62	63	70	80	25	49
28	28	31	39	38	43	41	19	27
32	26	43	46	54	48	32	28	33
33	12	28	24	25	26	32	16	16
36	1	2	1	0	0	- 7	1	0

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
39		-	-	-	-	-	-	-
40	1	2	1	1	1	- 5	1	1
41	17	23	20	17	22	19	14	14
42	16	12	10	16	7	- 24	9	9
43	15	28	23	22	23	4	19	20
44	16	35	34	22	40	71	16	18
45	12	26	23	8	24	19	16	17
46	20	36	25	23	26	25	22	21
47	32	44	10	18	6	- 35	29	23
49	23	48	3	16	4	- 3	29	20
50	18	31	16	14	17	20	19	15
51	10	20	1	3	- 2	- 10	12	9
59	-	-	-	-	-	-	-	-
60	2	4	2	2	2	- 5	3	3
61	4	12	9	8	9	13	7	6
62	4	6	1	0	0	- 4	4	3
63	6	18	1	6	1	- 4	11	8
64	1	5	0	1	0	2	3	2
65	10	29	9	10	10	29	14	10
68	4	8	4	10	5	6	5	4
69	15	30	21	21	22	26	15	16
70	14	31	28	21	32	54	16	17
71	-	-	-	-	-	-	-	-
72	10	18	17	16	28	19	11	12
73	15	30	28	34	32	37	17	19
74	23	37	45	38	45	11	13	31

District No.	Observed T_{ij}	Model No. 1	Model No. 2	Model No. 3	Model No. 4	Model No. 5	Model No. 6	Model No. 7
75	36	47	54	51	60	73	27	36
78	25	45	46	44	54	91	23	26
79	-	-	-	-	-	-	-	-
82	11	17	11	12	11	9	10	9
83	16	14	13	13	15	23	15	16
84	-	-	-	-	-	-	-	-
85	-	-	-	-	-	-	-	-
86	-	-	-	-	-	-	-	-
89	-	-	-	-	-	-	-	-
TOTAL	1,278	1,299	1,329	1,382	1,435	1,393	755	1,039
DIFFERENCE		+ 21	+ 51	+ 104	+ 157	+ 115	- 523	- 239
% DIFFERENCE OF TOTAL		+1.6%	+ 4%	+8.1%	+12.3%	+8.9%	-40.9%	-18.7%

Model No. 1 $T_{ij} = -.426 + .00504\ O_i + .00461\ D_j$

Model No. 2 $T_{ij} = 1.86 + .00552\ O_i + .00539\ D_j - .0547\ \mathrm{DIST}$

Model No. 3 $T_{ij} = 1.41 + .00524\ O_i + .00516\ D_j - .0460\ \mathrm{DIST} - 6.75\ \mathrm{AUTO}$
$+ 6.03\ \mathrm{CHOICE\ MSPLIT} + 2.63\ \mathrm{LOW\ RES}$

Model No. 4 $T_{ij} = 1.45 + .00761\ O_i + .00612\ D_j - .0642\ \mathrm{DIST}$

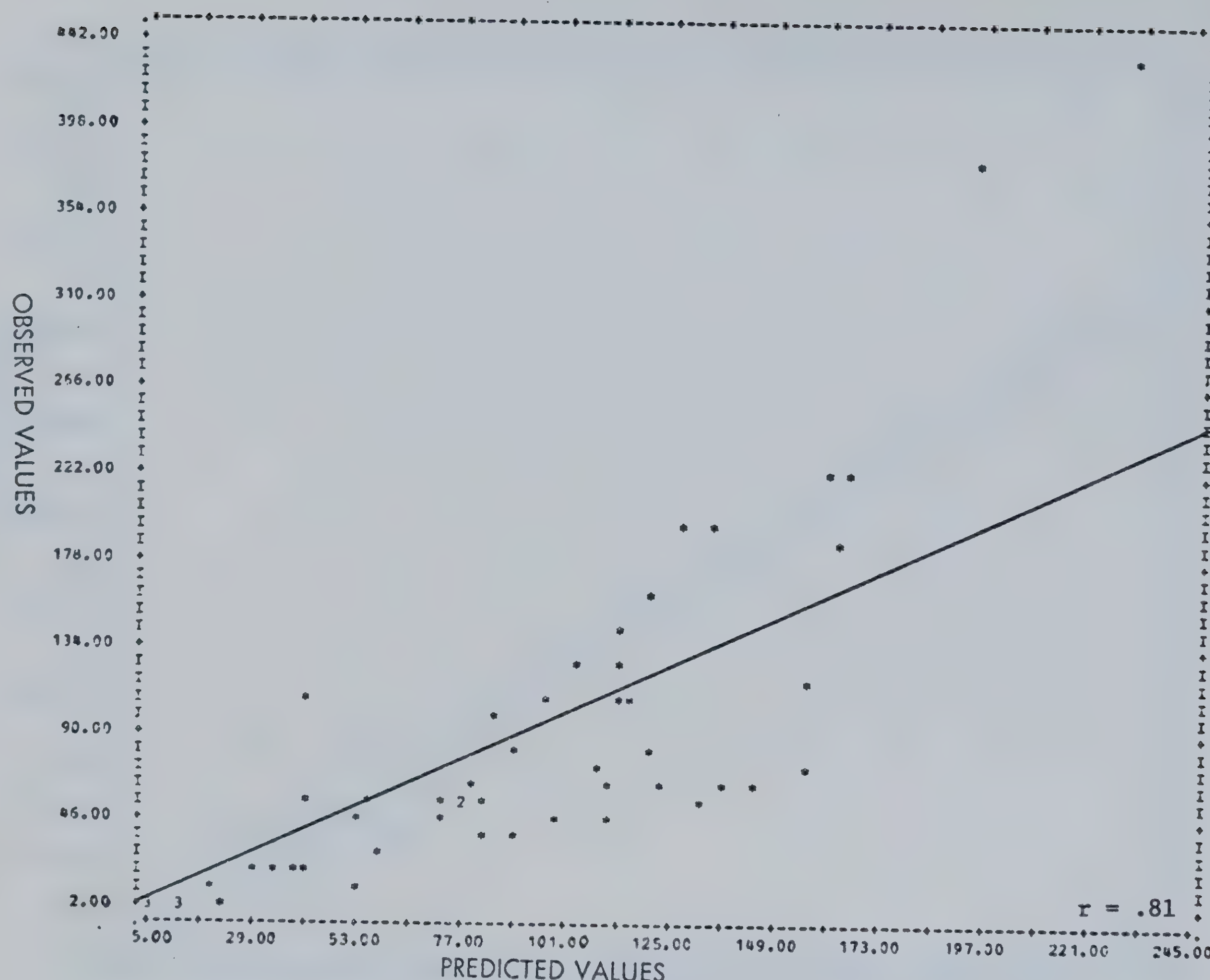
Model No. 5 $T_{ij} = -4.55 + .0216\ O_i + .00621\ D_j - .0699\ \mathrm{DIST}$

Model No. 6 $T_{ij} = -1.30 + .298\ O_i + .367\ D_j$

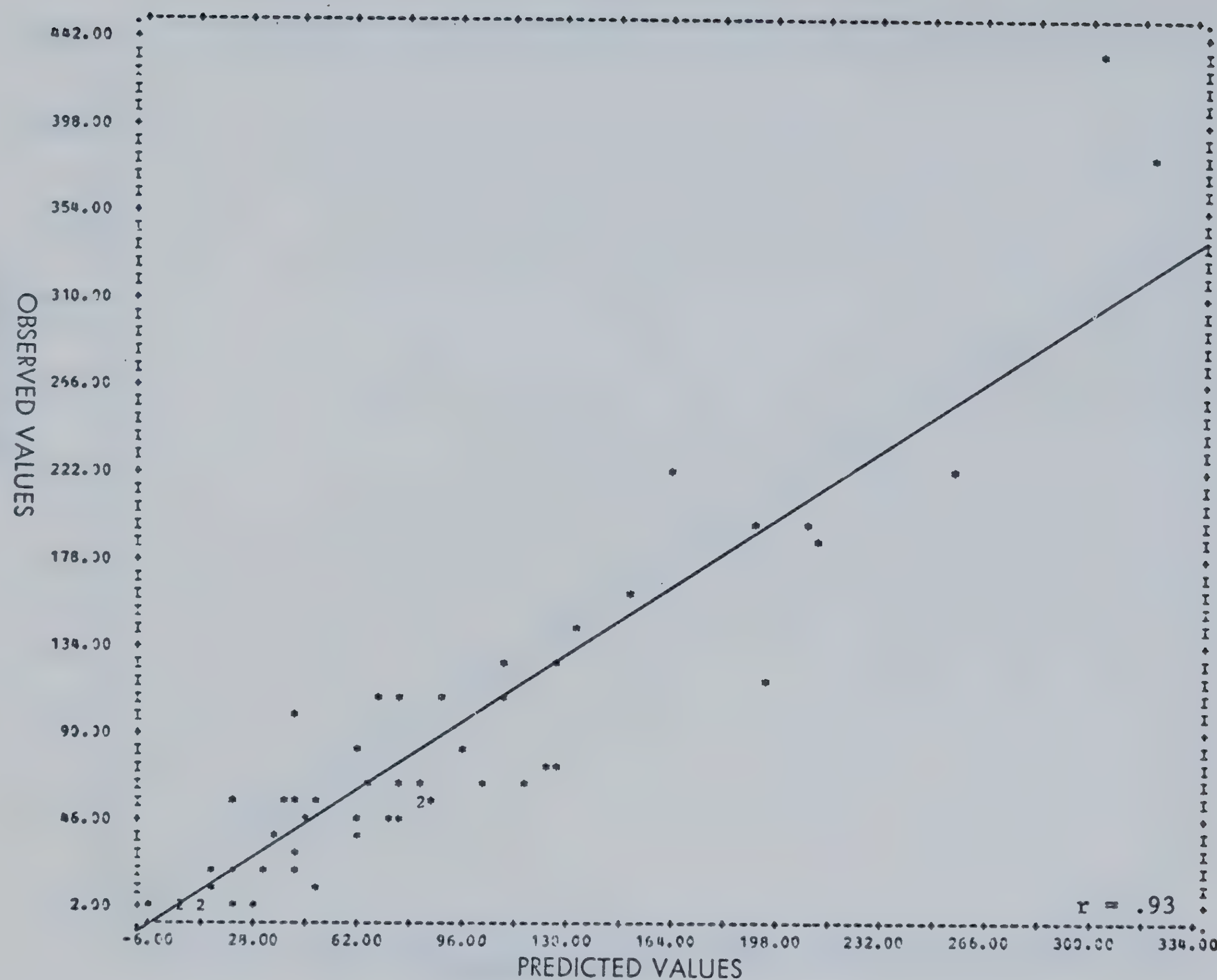
Model No. 7 $T_{ij} = -.623 + .378\ O_i + .434\ D_j - .643\ \mathrm{DIST}$

APPENDIX VIII

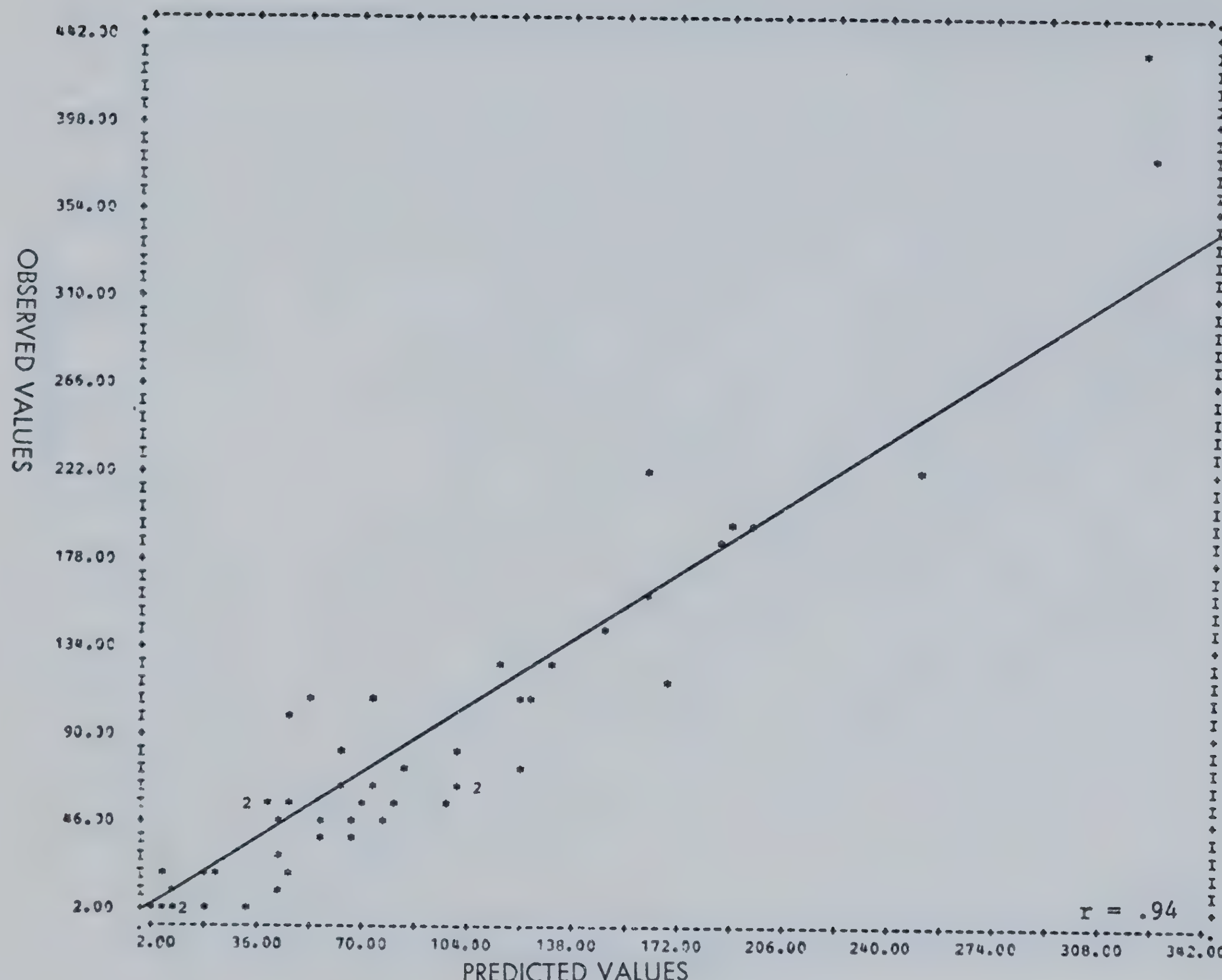
GRAPHICAL COMPARISON OF OBSERVED AND PREDICTED VALUES FOR THE NORTH WEST AND THE NORTH EAST INDUSTRIAL ZONES



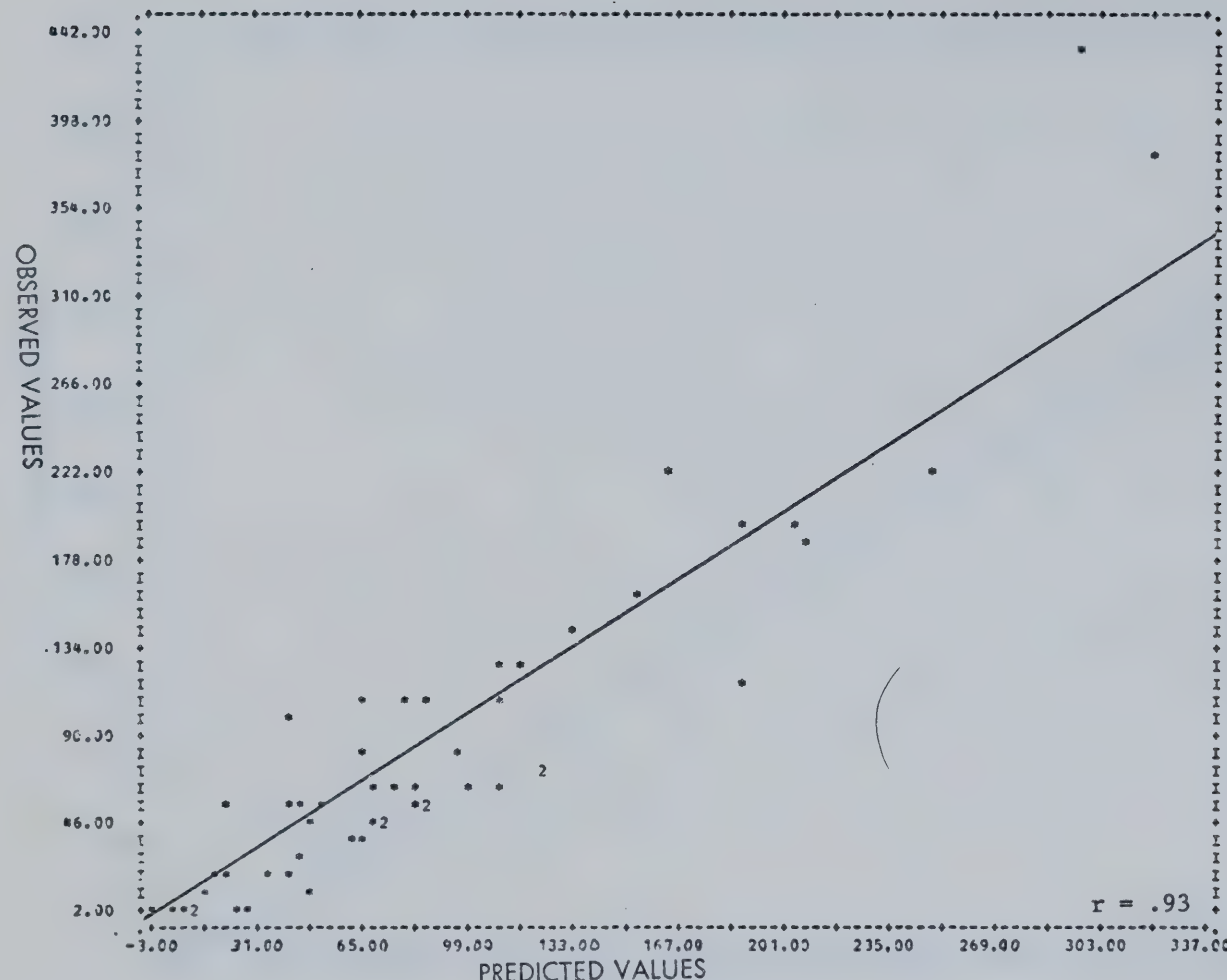
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 1



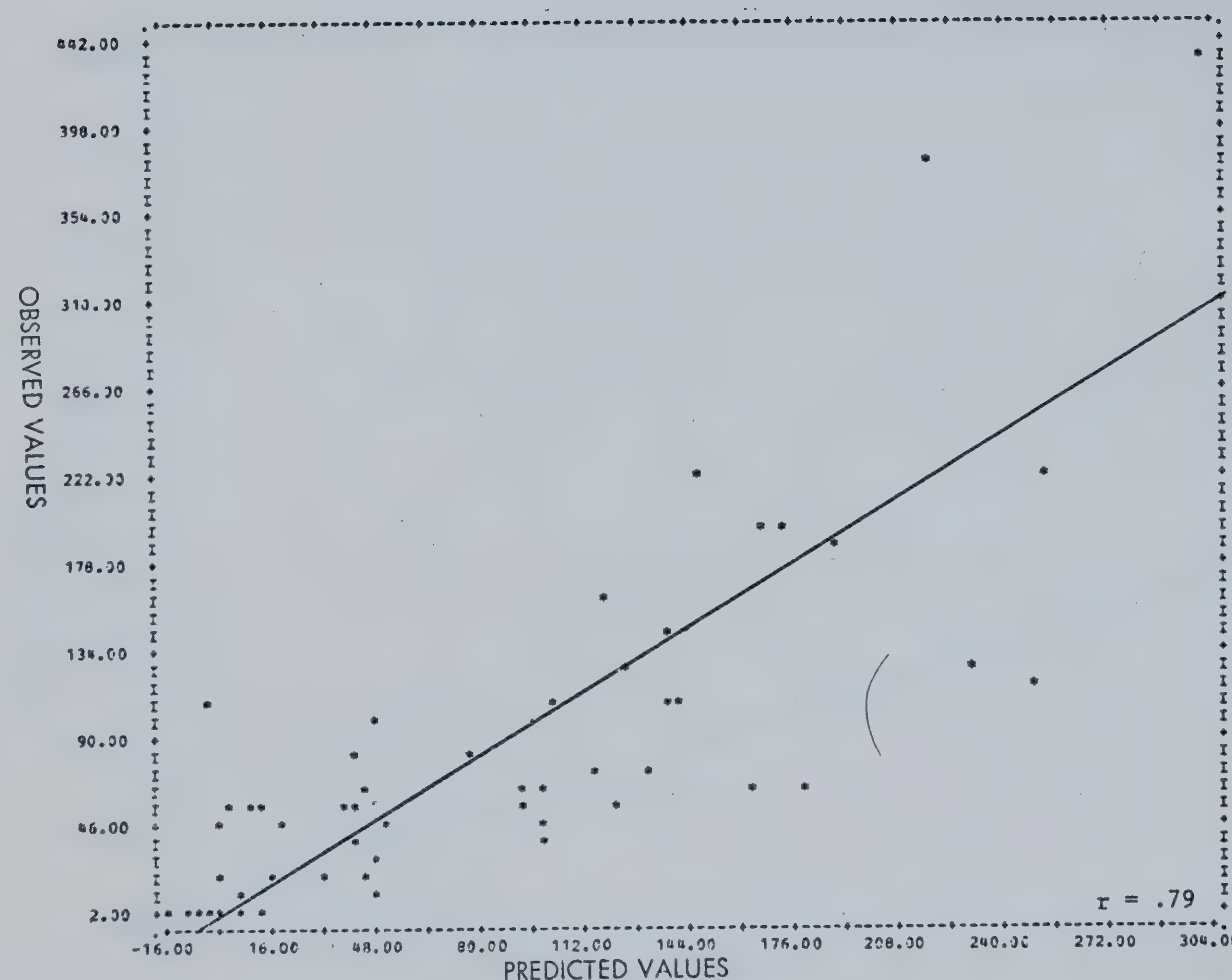
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 2



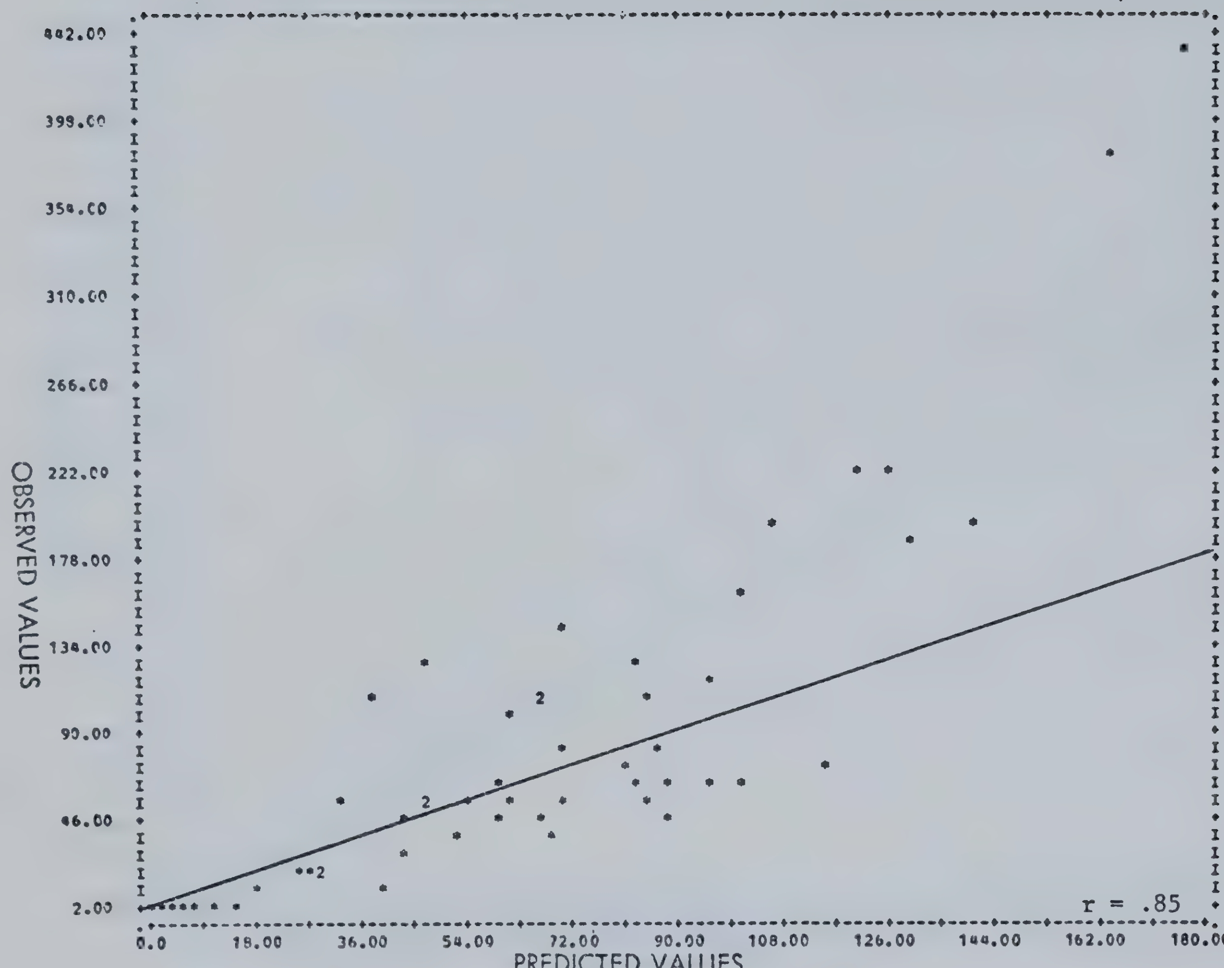
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 3



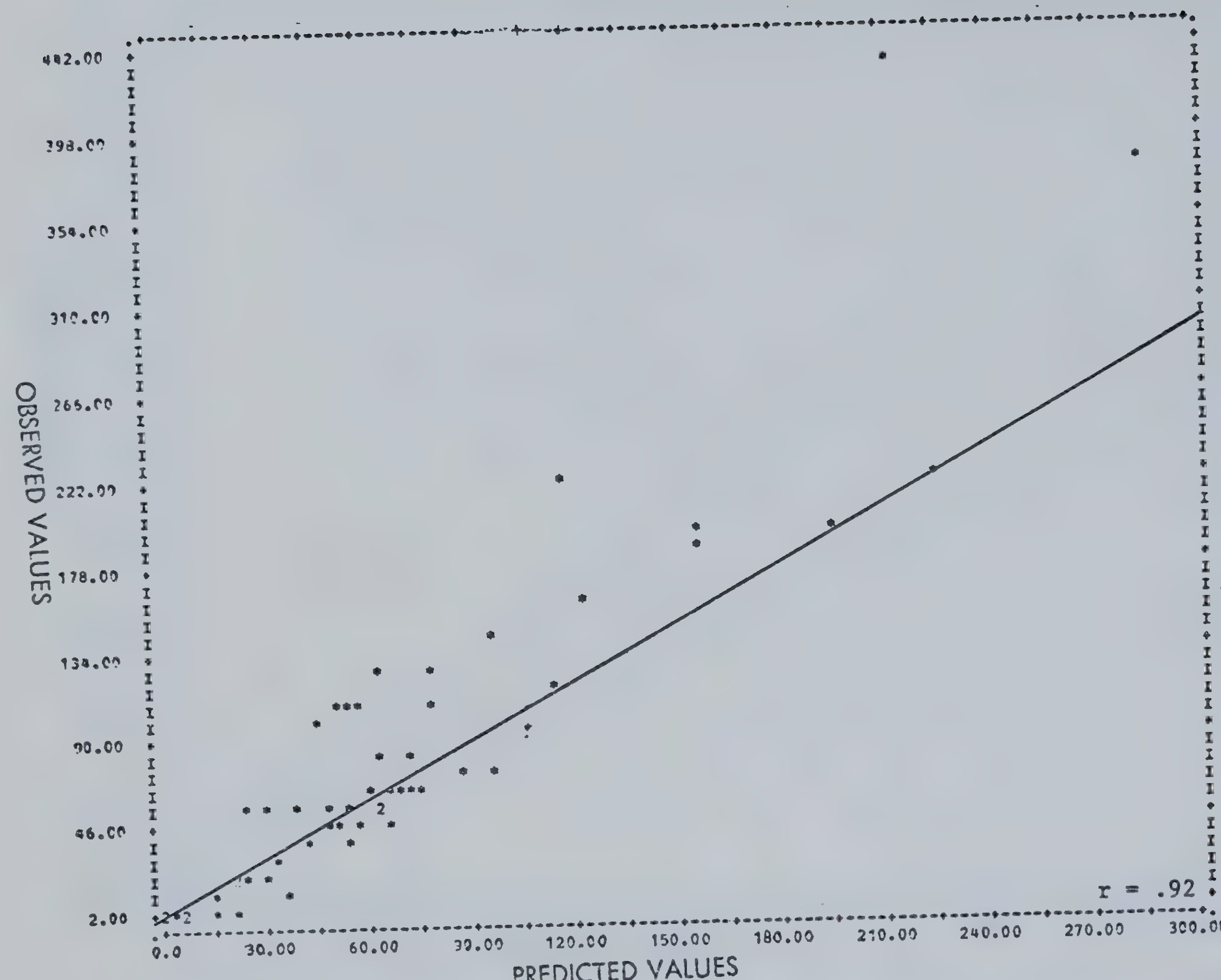
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 4



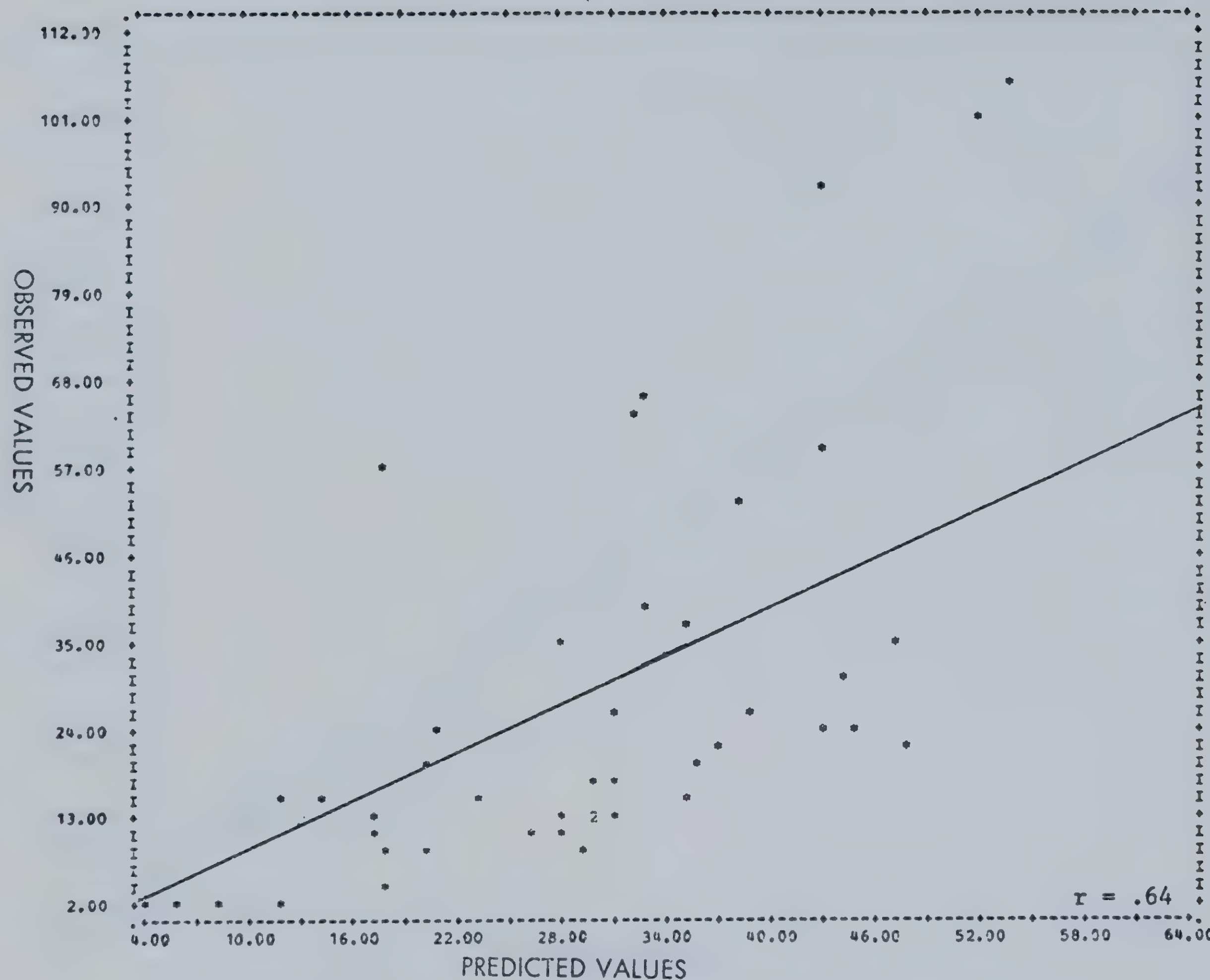
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 5



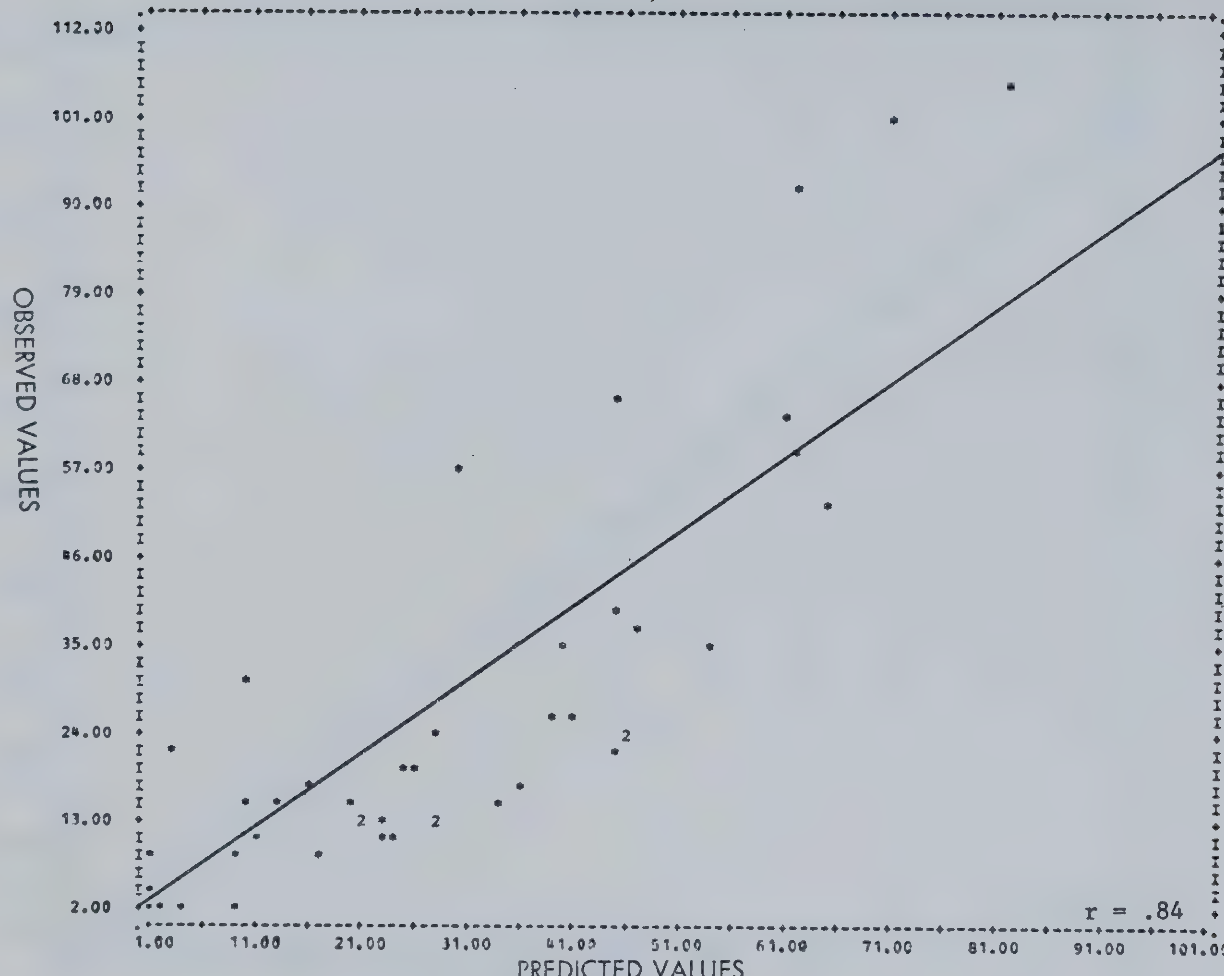
OBSERVED VERSUS PREDICTED VALUES FOR WORK TRIPS TO THE NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 6



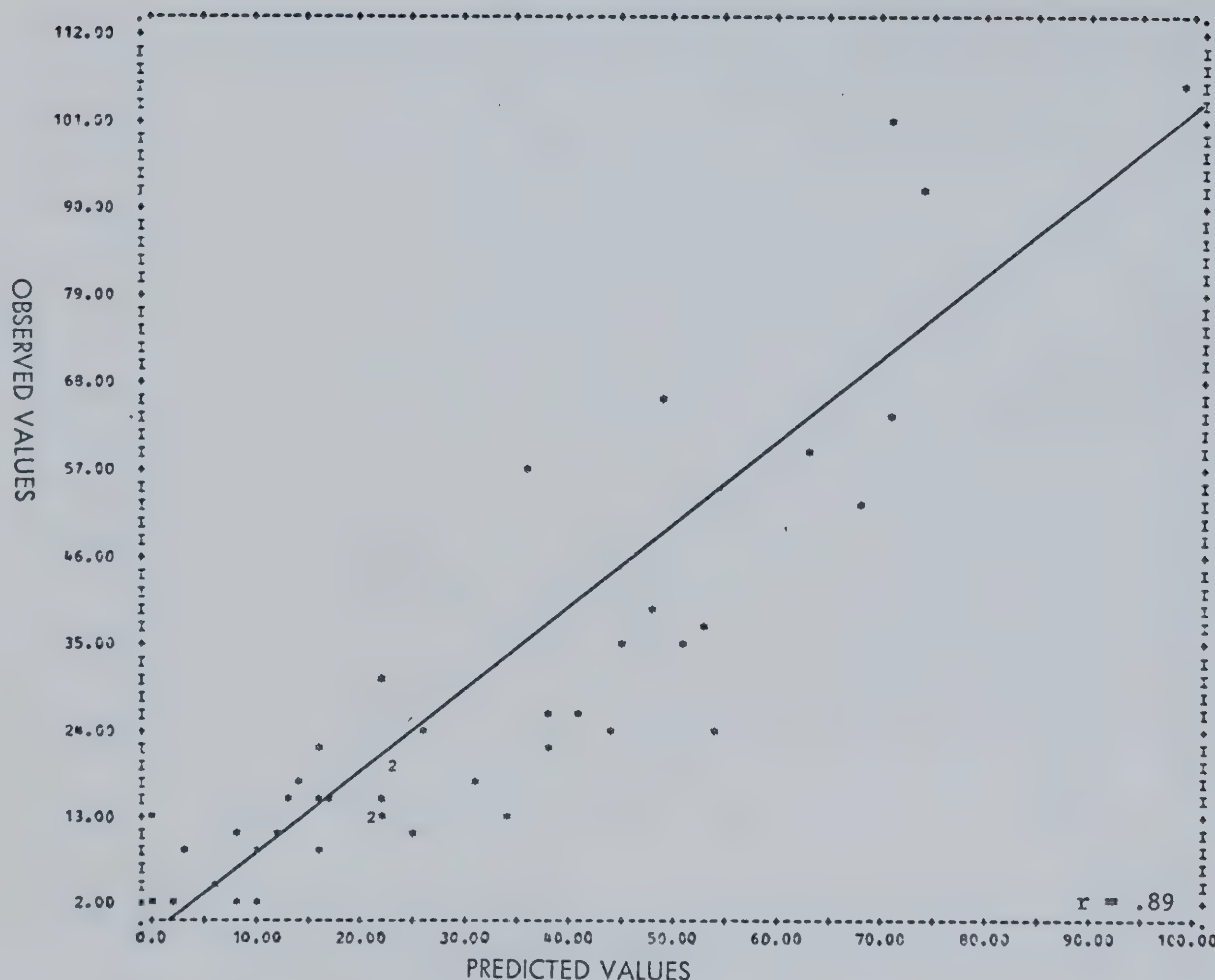
OBSERVED VERSUS PREDICTED VALUES FOR WORK TRIPS TO THE NORTH WEST INDUSTRIAL ZONES USING MODEL NO. 7



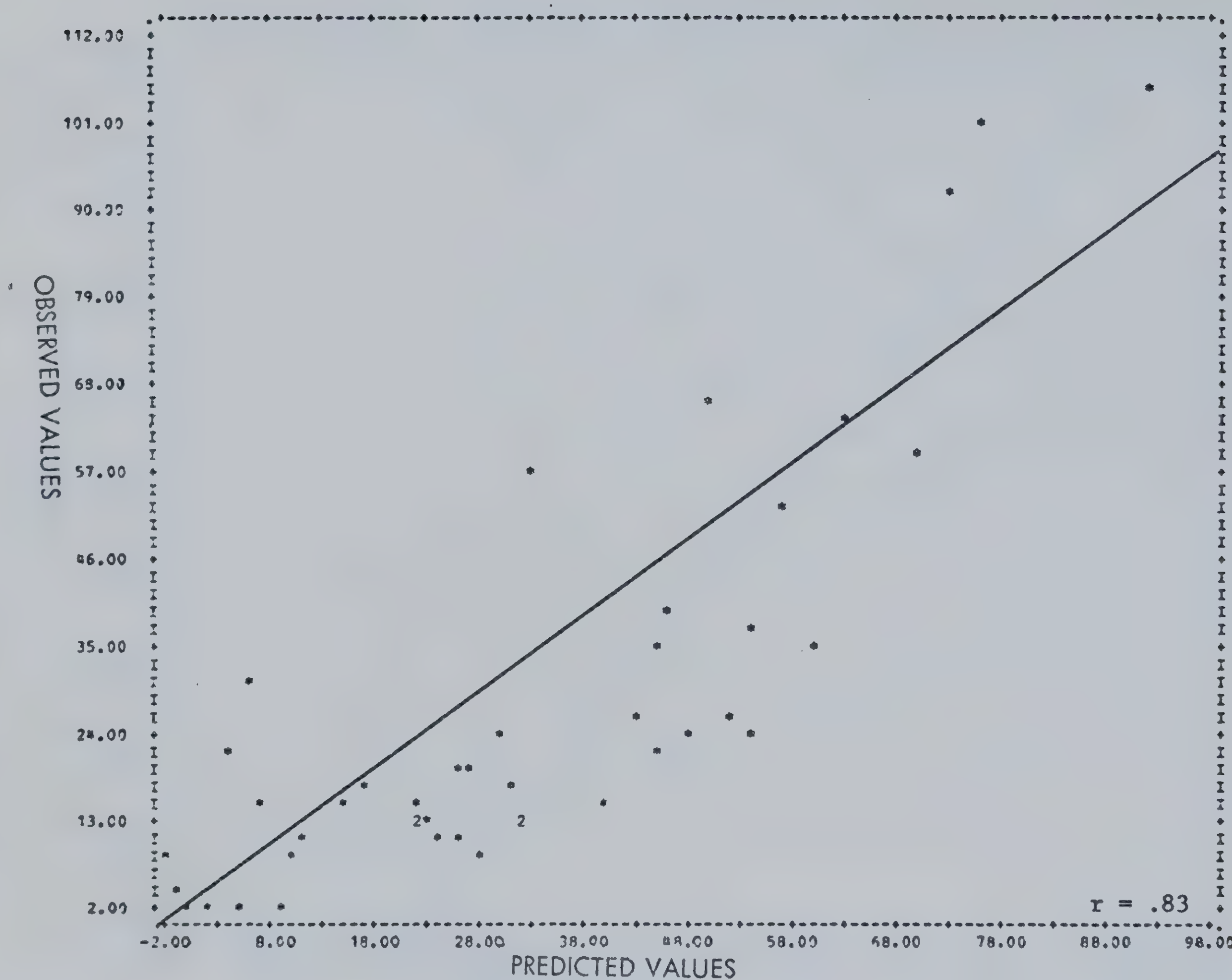
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST INDUSTRIAL ZONES USING MODEL NO. 1



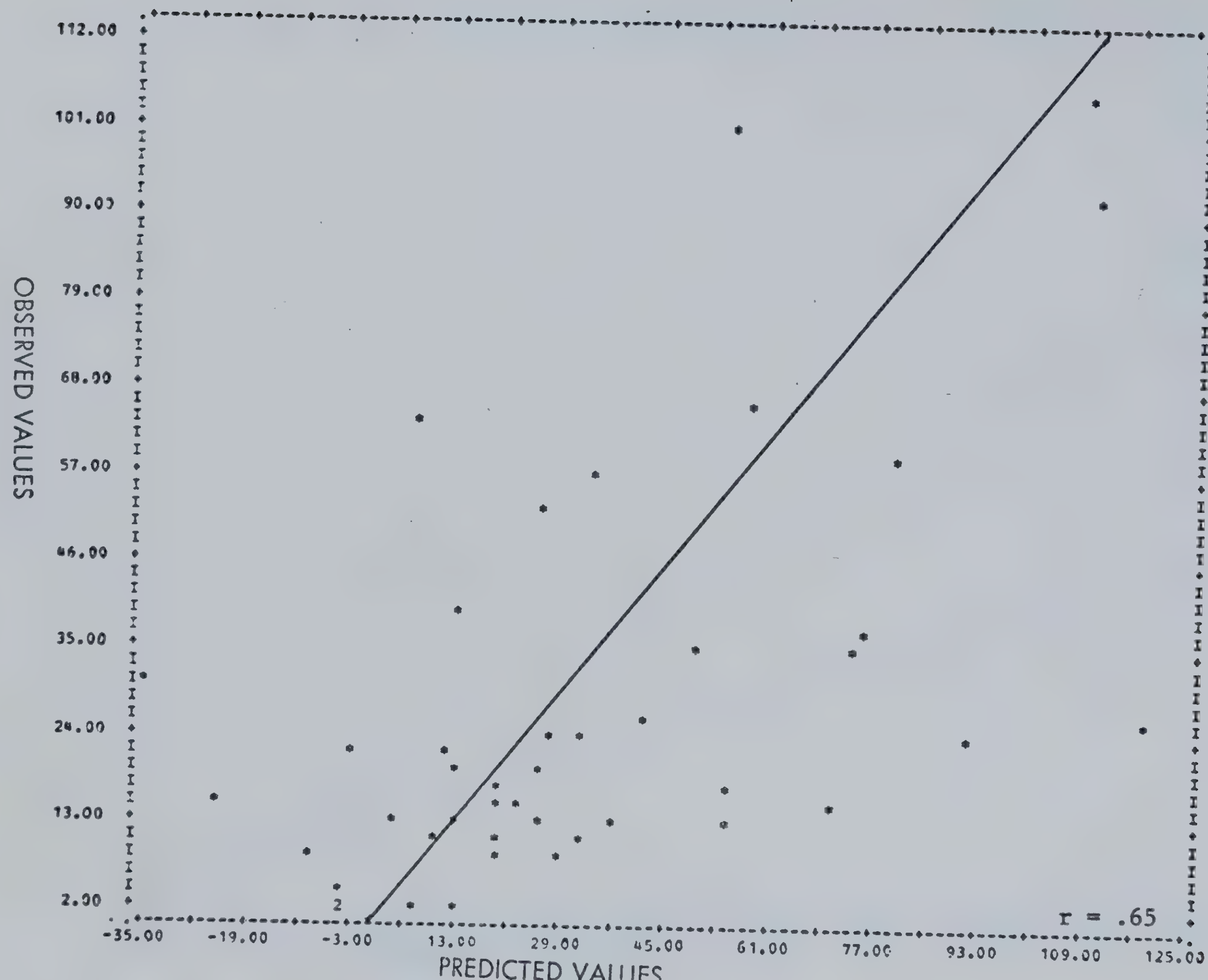
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST INDUSTRIAL ZONES USING MODEL NO. 2



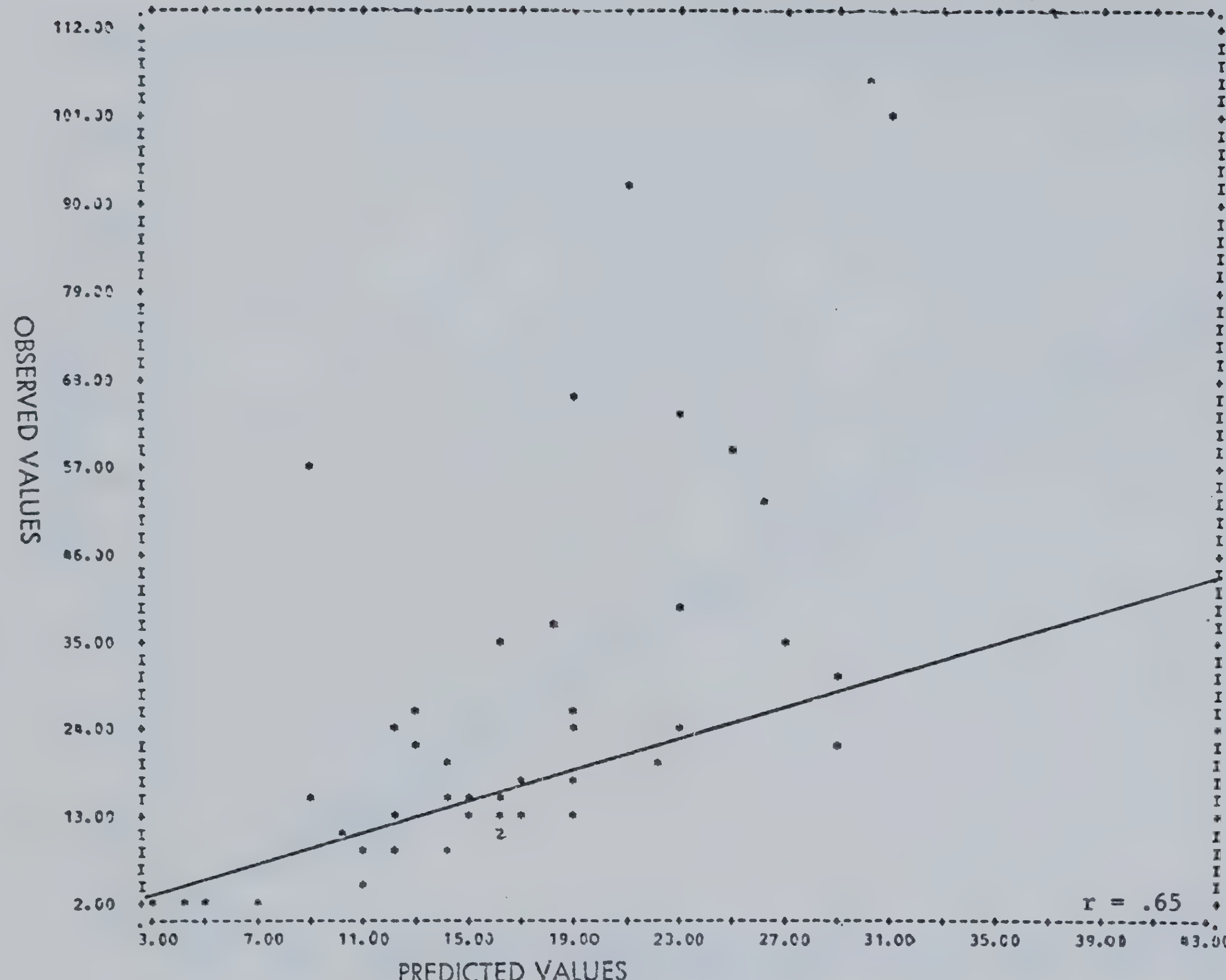
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST INDUSTRIAL ZONES USING MODEL NO. 3



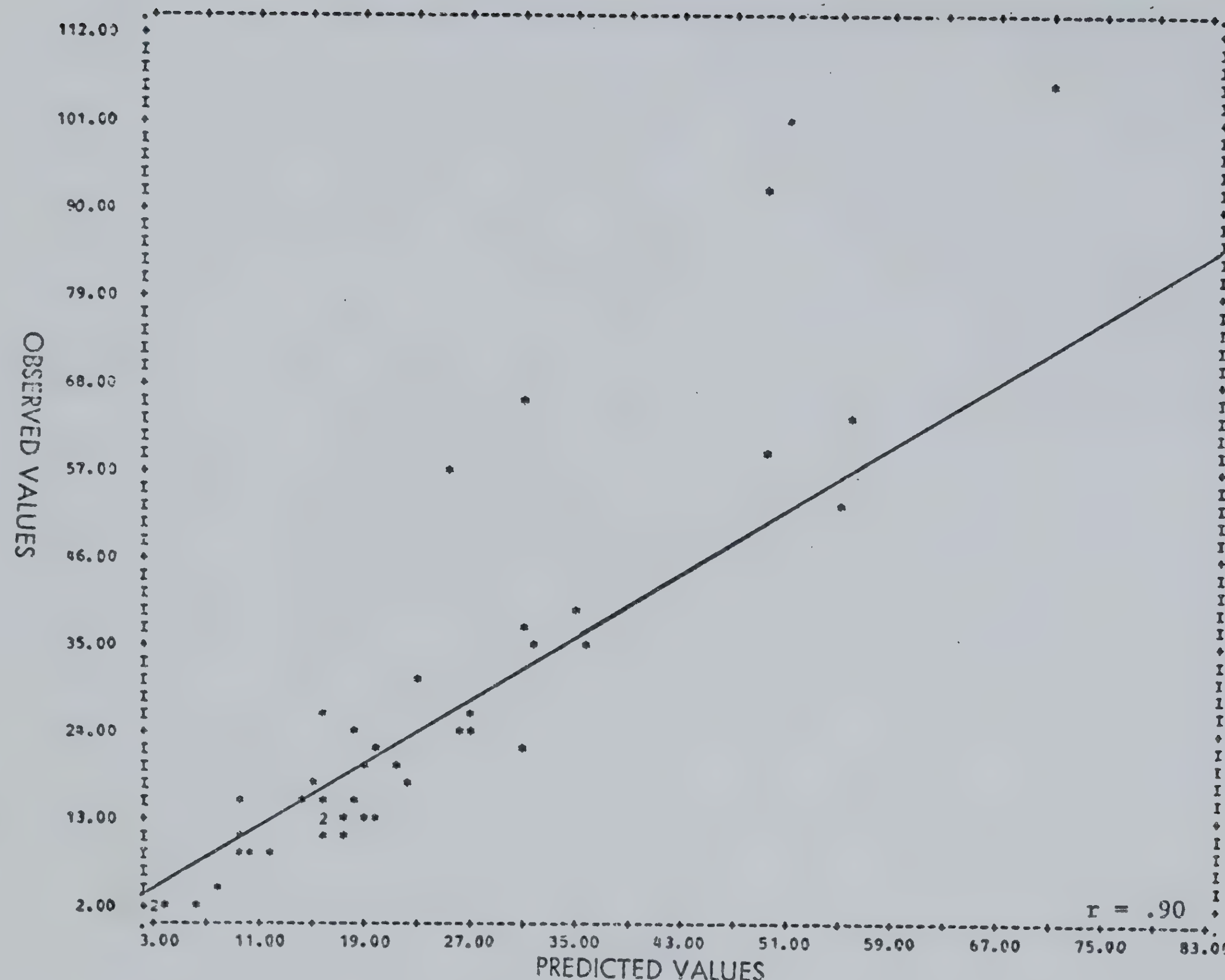
OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST INDUSTRIAL ZONES USING MODEL NO. 4



OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST
INDUSTRIAL ZONES USING MODEL NO. 5



OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST INDUSTRIAL ZONES USING MODEL NO. 6



OBSERVED VERSUS PREDICTED VALUES FOR THE NORTH EAST INDUSTRIAL ZONES USING MODEL NO. 7